Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network June 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about five hours after the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators report (by telephone) field estimates greater than 10 pCi/m^3 (except for Hawaii, Alaska, and Puerto Rico, which report 5 pCi/m^3) to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Field estimates and laboratory measurements of daily concentrations and the estimated ages for selected samples are reported in the monthly RSN report (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Sampling

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1,800 cubic meters of air are drawn through a filter during the 24-hour sampling period. The filters are forwarded to the RSN laboratory in Rockville, Maryland, where the gross beta activity is measured 4 days after the sampling period and again 7 days later if the net count rate is 2,000 cpm or higher. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated and the activity at time of collection determined.[1]

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

Figure 1. Radiation Surveillance Network sampling locations

The total precipitation is sampled continuously at most RSN stations on a daily basis, using funnels with collection areas of 0.4 square meter. If the rainfall exceeds 0.02 inch, the precipitation sample is analyzed for gross beta activity (*1*). Additionally, analyses for specific radionuclides may be performed.

In the laboratory, the gross beta activity in evaporated precipitation samples is calculated by the same method used for analyzing the air filters. Total deposition for the sample is calculated by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nCi/m^2, C is the concentration in pCi/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month.

Selected air and precipitation samples are analyzed by gamma spectroscopy to determine the presence of fresh fission products. This method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the complex gamma spectra.

Results

Monthly values of gross beta activity in air, total deposition and depth of precipitation are given in table 1 for June 1965. Time profiles of gross beta activity in air for eight stations are shown in figure 2.

Five air samples contained gross beta activities greater than 5 pCi/m^3; these were:

Location	Date	Activity at collection (pCi/m^3)
El Paso, Texas	June 1	7.8
	June 2	5.6
Phoenix, Arizona	June 2	6.7
Las Vegas, Nevada	June 1	9.5
	June 2	6.7

Of the 1,903 air samples and 357 precipitation samples collected during June 1965, 266 air samples and one precipitation sample were analyzed by gamma spectroscopy. All of these contained the fresh fission products ^{140}BaLa, ^{95}ZrNb, ^{103}Ru and ^{141}Ce at low levels. In addition, long-lived radionuclides, including ^{144}CePr, ^{137}Cs, and ^{106}RuRh, were present.

Table 1. Gross beta activity in surface air and precipitation, June 1965

Station location		Air surveillance						Precipitation measurements	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD*	Total depth (mm)	Total deposition [b] (nCi/m²)
		Air	Pptn	Maximum	Minimum	Average [a]			
Ala:	Montgomery	30	10	1.62	<0.10	<0.53	May 65	100.9	<20.5
Alaska:	Adak	27		0.17	<0.10	<0.11	Sep 65	NS	
	Anchorage	29	7	0.32	<0.10	<0.14	May 65	21.9	<4.6
	Attu Island	25		0.33	<0.10	<0.14	Dec 64	NS	
	Fairbanks	21	5	0.56	<0.10	<0.21	Jun 65	26.3	<6.9
	Juneau	20	8	0.43	<0.10	<0.15	Jul 65	91.7	<18.4
	Kodiak	14		0.21	<0.10	<0.12	Aug 65	NS	
	Nome	NS					Feb 65		
	Point Barrow	30		0.25	<0.10	<0.13	Jan 65	NS	
	St. Paul Island	29		0.29	<0.10	<0.11	Mar 65	NS	
Ariz:	Phoenix	29		6.67	0.20	1.60	Jul 65	NS	
Ark:	Little Rock	26	5	1.36	0.15	0.70	Jun 65	57.5	<12.4
Calif:	Berkeley	28		0.39	<0.10	<0.23	Aug 65	NS	
	Los Angeles	30		1.32	0.18	0.38	Feb 65	NS	
C. Z:	Ancon	NS					Aug 65		
Colo:	Denver	27	4	4.30	0.19	1.03	Aug 65	69.8	<17.0
Conn:	Hartford	30	5	1.03	<0.10	<0.46	Jul 65	37.2	<8.5
Del:	Dover	22		0.79	0.16	0.44	May 65	NS	
D. C:	Washington	27	5	0.91	0.14	0.50	Feb 65	25.8	<7.1
Fla:	Jacksonville	28	10	0.76	<0.10	<0.31	Jun 65	221.5	<44.4
	Miami	23	9	1.62	<0.10	0.44	Jul 65	215.0	<43.1
Ga:	Atlanta	4		0.94	0.62	0.81	Apr 65	NS	
Guam:	Agana	28		4.45	<0.10	0.55	Apr 65	NS	
Hawaii:	Honolulu	30	2	0.66	<0.10	<0.27	Dec 64	18.0	<5.6
Idaho:	Boise	28	4	2.22	0.21	0.72	Dec 64	25.0	<8.1
Ill:	Springfield	29	6	1.03	0.22	0.60	Feb 65	101.2	<20.3
Ind:	Indianapolis	22	4	1.11	0.15	0.58	Apr 65	59.8	<15.3
Iowa:	Iowa City	30	6	1.12	0.22	0.60	Aug 65	78.6	<15.1
Kans:	Topeka	26	9	1.87	0.12	0.70	May 65	208.6	<56.3
Ky:	Frankfort	26	7	1.58	0.25	0.71	Feb 65	37.1	<8.5
La:	New Orleans	30	10	2.21	<0.10	<0.53	Feb 65	131.3	<27.9
Maine:	Augusta	30	9	1.60	<0.10	0.57	Mar 65	57.0	<12.9
	Presque Isle	22	7	1.27	0.12	0.50	Aug 65	49.9	<10.7
Md:	Baltimore	22	3	0.89	0.15	0.52	Jul 65	30.0	6.4
	Rockville	10		1.00	0.25	0.49	Jan 65	NS	
Mass:	Lawrence	29	7	1.34	<0.10	0.59	May 65	65.9	<22.2
	Winchester	28	9	1.17	<0.10	<0.49	Sep 65	86.6	<22.9
Mich:	Lansing	29	9	1.40	0.15	0.60	Jan 65	56.9	<12.2
Minn:	Minneapolis	21	8	0.89	0.27	0.49	Apr 65	152.9	<48.8
Miss:	Jackson	29	3	1.90	<0.10	0.75	Dec 64	33.2	<9.5
	Pascagoula	13		2.14	<0.10	0.71	Sep 65	NS	
Mo:	Jefferson City	30	8	1.33	0.13	0.66	Apr 65	168.0	<48.1
Mont:	Helena	30	10	2.25	<0.10	0.85	Sep 65	70.7	<16.7
Nebr:	Lincoln	17	1	1.40	<0.10	<0.46	Mar 65	29.8	<6.0
Nev:	Las Vegas	22		9.49	0.18	1.82	Jun 65	NS	
N. H:	Concord	22		1.80	<0.10	0.72	Feb 65	NS	
N. J:	Trenton	29	3	1.05	<0.10	0.52	Mar 65	12.0	<2.4
N. Mex:	Santa Fe	25	10	2.59	0.11	0.70	Sep 65	57.9	<15.6
N. Y:	Albany	21	9	1.29	<0.10	<0.59	Apr 65	36.1	<7.2
	Buffalo	24		1.62	<0.10	0.67	Aug 65	NS	
	New York	30		1.27	<0.10	0.44	Sep 65	NS	
N. C:	Gastonia	29	8	0.98	<0.10	<0.37	Aug 65	127.1	<25.4
N. Dak:	Bismarck	27	11	1.13	0.12	0.61	Jan 65	87.2	<22.1
Ohio:	Cincinnati	14		0.69	0.14	0.39	May 65	NS	
	Columbus	28	7	1.75	0.31	0.85	Mar 65	25.2	<7.0
	Painesville	30	8	1.83	<0.10	0.69	Jul 65	96.3	<20.4
Okla:	Oklahoma City	28		1.58	0.13	0.61	Jan 65	NS	
	Ponca City	28	11	1.14	<0.10	<0.34	Oct 65	121.4	<27.1
Ore:	Portland	28	4	1.02	0.17	0.45	Mar 65	16.2	<3.3
Pa:	Harrisburg	30	2	1.79	0.13	0.48	Apr 65	27.6	7.5
P. R:	San Juan	29	4	1.25	<0.10	0.46	Mar 65	143.2	<28.6
R. I:	Providence	28	5	1.01	<0.10	0.53	Jan 65	48.0	<10.6
S. C:	Columbia	25	12	0.66	<0.10	<0.30	Sep 65	212.3	<44.2
S. Dak:	Pierre	30	6	1.77	0.20	0.59	Jul 65	22.8	<9.5
Tenn:	Nashville	30	10	1.35	<0.10	0.52	Jan 65	87.8	<29.1
Tex:	Austin	30	5	1.54	<0.10	<0.50	May 65	39.7	<8.3
	El Paso	27	2	7.79	0.13	1.17	Jan 65	13.2	<3.4
Utah:	Salt Lake City	29	8	4.85	<0.10	1.70	Feb 65	133.3	<33.9
Vt:	Barre	26	8	1.33	<0.10	0.57	Jun 65	81.0	<20.2
Va:	Richmond	30	9	0.81	<0.10	0.42	Jun 65	95.1	<20.3
Wash:	Seattle	29	3	0.51	<0.10	0.24	May 65	11.1	4.9
	Spokane	30	1	1.44	0.11	0.62	Apr 65	13.2	<2.6
W. Va:	Charleston	28	7	0.94	0.12	0.50	Sep 65	54.7	<16.4
Wis:	Madison	30	6	1.13	0.18	0.47	Jun 65	38.6	<12.0
Wyo:	Cheyenne	29	8	3.75	0.20	1.02	Jun 65	98.2	60.4
Network summary [c]		1,903	357	9.49	<0.10	<0.56		74.6	<18.5

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.
[b] If any individual precipitation samples have activity concentrations under 200 pCi/liter, a "less than" sign is placed before the total deposition value.
[c] For the network summary, all averages are arithmetic means of station averages.
Key to symbols: NS, no sample collected. Blank indicates no report received.

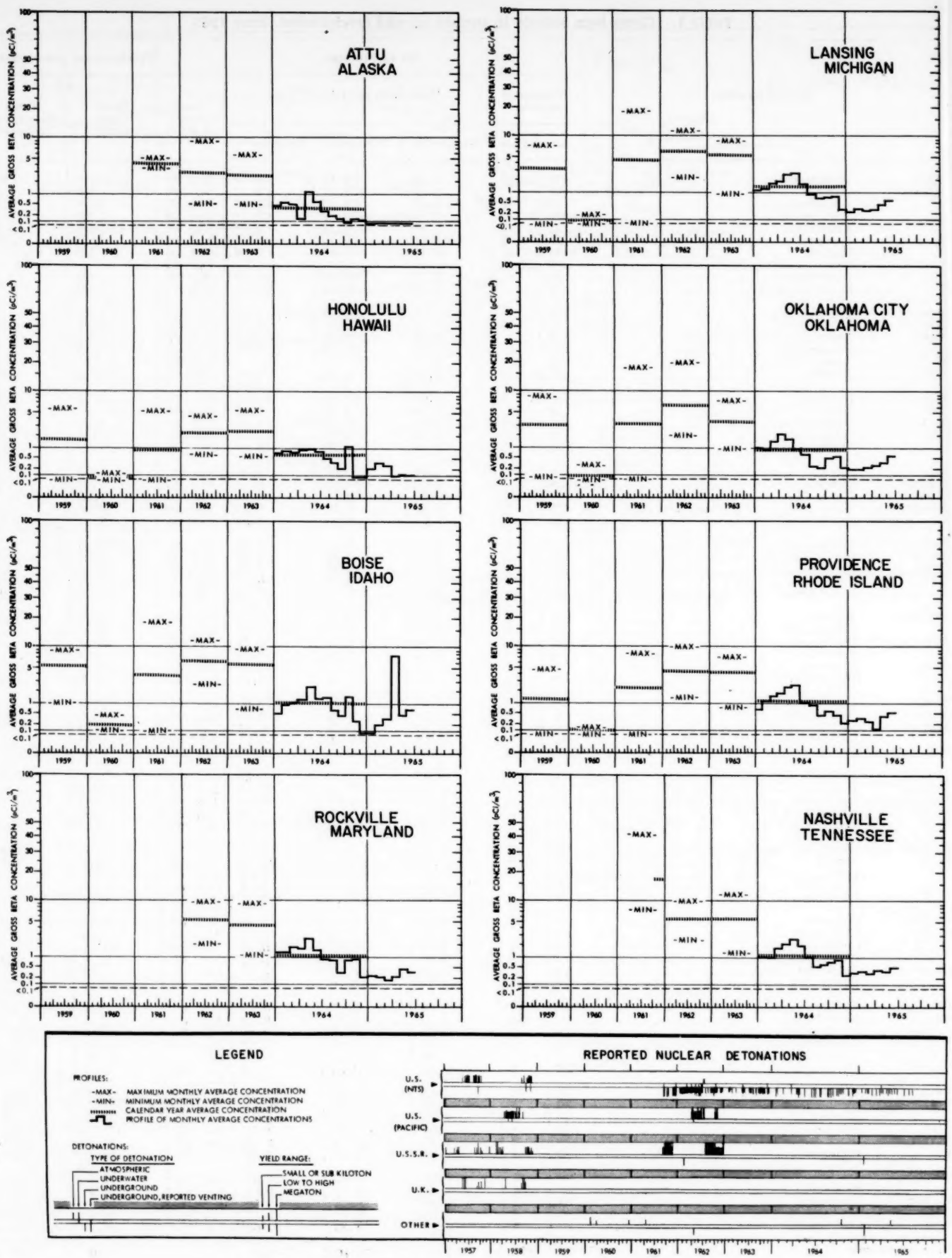

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959–June 1965

2. National Air Sampling Network Second Quarter 1965

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. The resulting data aid in the detection of trends in levels of pollution with respect to time, location, population density, climate and other factors.

Gross beta activity in air

NASN stations (figure 3) are manned by cooperating Federal, State and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, the NASN consists of 240 sampling stations, 175 of which are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass-fiber filters on a biweekly random sampling schedule. They are sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Second quarter 1965 gross beta activities in air are given in table 2. An annual summary for 1964 was presented in the April 1965 issue of Radiological Health Data (*5*).

Figure 3. National Air Sampling Network stations

Table 2. Gross beta activity in surface air, NASN, second quarter 1965

(Concentrations in pCi/m³)

	Station Name	Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	6	1.1	0.4	0.6
	Huntsville	6	1.1	0.2	0.7
	Montgomery	7	1.1	0.3	0.6
Alaska:	Anchorage	6	0.4	<0.1	0.2
Ariz:	Grand Canyon Park *	7	1.3	0.4	0.9
	Paradise Valley *	5	2.0	0.6	1.1
	Phoenix	6	1.7	0.6	1.1
	Tucson	7	8.8	0.5	1.8
Ark:	Little Rock	4	1.4	0.2	0.8
	Montgomery County *	6	0.7	0.1	0.4
Calif:	Glendale	7	1.1	0.3	0.6
	Humboldt County *	7	0.3	0.1	0.2
	Long Beach	6	1.0	0.3	0.6
	Los Angeles	6	1.0	0.3	0.5
	Oakland	5	0.3	0.2	0.2
	San Diego	7	0.8	0.3	0.5
	San Francisco	7	0.4	0.2	0.4
Colo:	Denver	5	1.6	0.2	0.7
	Montezuma County *	7	1.4	0.6	0.9
Conn:	Hartford	6	1.1	0.1	0.6
	New Britain	6	1.2	0.2	0.7
	New Haven	6	1.2	0.2	0.6
	Norwich	6	1.2	0.1	0.6
	Waterbury	6	1.3	0.2	0.6
Del:	Kent County *	5	0.9	0.2	0.5
	Newark	5	1.3	0.2	0.6
	Wilmington	6	1.1	0.2	0.6
D. C:	Washington	6	1.3	0.1	0.6
Ga:	Atlanta	6	0.9	0.3	0.6
Hawaii:	Honolulu	7	3.0	0.1	1.1
Idaho:	Boise	6	1.2	0.5	0.9
	Butte County *	5	1.4	0.6	0.8
Ill:	Chicago	7	0.8	0.2	0.5
	East St. Louis	6	1.5	0.4	0.9
	Joliet	6	0.6	0.3	0.5
	North Chicago	5	0.9	0.2	0.5
	Rockford	7	0.9	0.3	0.6
	Springfield	6	0.7	0.3	0.5
Ind:	East Chicago	6	0.8	0.2	0.5
	Hammond	5	0.9	0.2	0.6
	Indianapolis	6	1.2	0.3	0.6
	Parke County *	6	1.1	0.2	0.6
	Portage	5	1.1	0.4	0.7
	Beverly Shores	6	0.8	0.2	0.6
	Dunes Police Post No. 1	6	1.0	0.3	0.6
	Dunes State Park	5	1.0	0.2	0.5
	Ogden Dunes	5	0.6	0.1	0.4
	South Bend	5	1.8	0.5	1.0
	Terre Haute	5	1.5	0.7	1.1
Iowa:	Cedar Rapids	6	0.6	0.2	0.4
	Delaware County *	5	0.6	0.2	0.4
	Des Moines	6	1.1	0.2	0.5
Kans:	Topeka	6	1.6	0.2	0.7
	Wichita	6	1.0	0.3	0.6
Ky:	Lexington	5	1.4	0.2	0.7
	Louisville	5	0.6	0.2	0.4
La:	New Orleans	6	1.3	0.4	0.7
	Shreveport	6	1.3	0.2	0.7
Maine:	Acadia Nat'l. Park *	6	0.7	0.2	0.5
	Portland	5	1.3	0.2	0.5
Md:	Baltimore	6	1.6	0.1	0.7
	Calvert County *	6	0.8	0.1	0.5
Mass:	Brockton	6	1.2	0.2	0.6
	Lawrence	6	2.0	0.1	0.8
	Lowell	6	2.0	0.2	1.0
	New Bedford	5	1.5	0.1	0.7
Mich:	Detroit	6	1.5	0.4	0.8
	Flint	5	1.3	<0.1	0.6
	Grand Rapids	6	0.8	0.2	0.5
	Trenton	5	1.3	0.4	0.8
Minn:	Minneapolis	7	0.8	0.1	0.4
	St. Paul	6	0.8	0.1	0.4
Miss:	Jackson	6	1.6	0.2	0.7
	Jackson County *	6	1.4	0.2	0.6
Mo:	Kansas City	5	0.6	0.3	0.4
	St. Louis	5	1.2	0.4	0.6
	Shannon County *	6	0.9	0.1	0.5
Mont:	Glacier Nat'l. Park *	5	1.0	0.2	0.6
	Helena	5	1.4	0.5	0.9
Nebr:	Omaha	5	0.8	0.3	0.6
	Thomas County *	6	0.9	0.1	0.5
Nev:	Las Vegas	6	1.9	0.7	1.2
	Reno	7	1.4	0.5	1.0
	White Pine County *	6	1.4	0.4	0.8
N. H:	Concord	6	1.0	0.2	0.6
	Coos County *	5	0.8	0.3	0.4
N. J:	Bayonne	6	1.8	0.2	0.8
	Bridgeton	5	0.5	0.1	0.3
	Pemberton	6	1.0	0.2	0.7
	Marlton	6	1.3	0.1	0.6
	Glassboro	5	1.1	0.1	0.6
	Hamilton	6	1.4	0.1	0.8
	Jutland	6	1.1	0.1	0.5
	Jersey City	6	1.3	0.1	0.6
	Newark	6	2.0	0.1	0.7
	New Brunswick	6	0.9	0.1	0.6
	Paterson	6	1.8	0.1	0.7
	Perth Amboy	5	1.6	0.2	0.8
	Princeton	5	0.7	0.2	0.5
N. Mex:	Albuquerque	6	1.6	0.3	1.0
	Rio Arriba County *	6	2.6	0.5	1.2
N. Y:	Cape Vincent *	6	1.2	0.3	0.6
	New York City	5	1.2	0.2	0.5
N. C:	Charlotte	6	1.0	0.4	0.6
	Cape Hatteras *	5	0.8	0.2	0.4
Ohio:	Akron	6	1.3	0.4	0.8
	Cincinnati	6	1.2	0.4	0.7
	Cleveland	5	3.6	0.5	1.4
	Columbus	6	1.4	0.5	0.8
	Toledo	6	1.5	0.4	0.9
	Youngstown	6	1.3	0.5	0.8
Okla:	Cherokee County *	5	1.3	0.2	0.8
	Oklahoma City	6	0.9	0.2	0.5
	Tulsa	6	0.8	0.2	0.5
Ore:	Curry County *	7	0.4	0.1	0.3
	Eugene	6	0.5	0.1	0.3
	Medford	6	0.8	0.1	0.6
	Portland	5	0.5	0.2	0.3
Pa:	Allentown	5	1.7	0.1	0.5
	Altoona	6	1.4	0.4	1.0
	Bethlehem	6	2.0	0.1	0.8
	Pipersville	6	1.7	0.1	0.6
	Embreeville	5	1.0	0.2	0.5
	Clarion County *	6	1.8	0.3	0.8
	Erie	6	1.6	0.4	0.8
	Johnstown	6	0.8	0.2	0.6
	Lancaster	6	1.1	0.1	0.7
	Eagleville	6	1.2	0.2	0.6
	Sanatoga	6	1.8	0.1	0.6
	Philadelphia	6	1.1	0.3	0.5
	Pittsburgh	6	1.2	0.4	0.7
	Reading	6	2.1	0.1	0.6
	Warminster	6	2.9	0.2	0.9
	West Chester	5	0.8	0.2	0.5
	York	6	1.4	0.3	0.9
P. R:	Bayamon	7	2.0	0.3	0.6
	Guayanilla	6	0.7	0.1	0.3
	Ponce	5	1.1	0.2	0.4
	San Juan	4	0.9	0.2	0.5
R. I:	East Providence	6	0.8	<0.1	0.4
	Providence	6	2.0	0.2	0.8
	Washington County *	6	1.4	0.2	0.7
S. C:	Charleston	6	1.1	0.2	0.6
	Richland County *	5	0.8	0.1	0.4
	Spartanburg	7	1.3	0.2	0.7
S. Dak:	Black Hills Forest *	6	0.9	0.2	0.7
	Sioux Falls	6	0.8	0.1	0.4
Tenn:	Chattanooga	6	1.2	0.4	0.8
	Knoxville	6	1.2	0.4	0.7
	Memphis	6	1.1	0.1	0.6
	Nashville	6	1.0	0.3	0.6
Tex:	Dallas	6	1.8	0.2	0.8
	Houston	6	1.0	0.4	0.6
	Matagorda County *	7	1.0	0.2	0.6
	San Antonio	6	0.6	0.2	0.4
Utah:	Salt Lake City	5	2.5	0.2	0.9
Vt:	Burlington	6	1.2	0.1	0.6
	Orange County *	5	1.4	0.3	0.8
Va:	Hampton	6	1.3	0.3	0.6
	Lynchburg	6	1.2	0.1	0.7
	Norfolk	7	1.5	0.3	0.7
	Shenandoah Nat'l. Park *	6	1.2	0.3	0.7
	Portsmouth	6	0.8	0.3	0.5
	Richmond	6	1.5	0.4	0.8
	Roanoke	6	1.0	0.4	0.7
Wash:	Seattle:	7	0.8	0.2	0.4
W. Va:	Charleston	6	0.8	0.1	0.5
	Weirton	6	1.2	0.5	0.8
	Wheeling	6	1.3	0.5	0.8
Wis:	Door County *	6	0.8	0.1	0.5
	Kenosha	6	2.0	0.2	0.9
	Madison	6	1.0	0.2	0.6
	Milwaukee	6	0.8	0.2	0.5
Wyo:	Cheyenne	6	1.4	0.2	0.8
	Yellowstone Park *	6	1.1	0.4	0.8
Network summary			3.6	<0.1	0.7

* Denotes nonurban station.

3. Canadian Air and Precipitation Monitoring[2] June 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 4) are located at airports, where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*6-10*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa.

For analysis purposes a 2-inch diameter disk is cut from each filter and counted with a thin-end window, glass-flow, Geiger-Mueller counter system calibrated with a strontium–90—yttrium–90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for June 1965 are given in table 3.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter, together with the polyethylene liner, is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin-end window, Geiger-Mueller counter calibrated with a strontium–90—yttrium–90 source. Gross beta activities in precipitation for June 1965 are given in table 3.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. Where the June 1965 gross beta deposition is given in table 3, the deposi-

[2] Prepared from information and data in the July 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

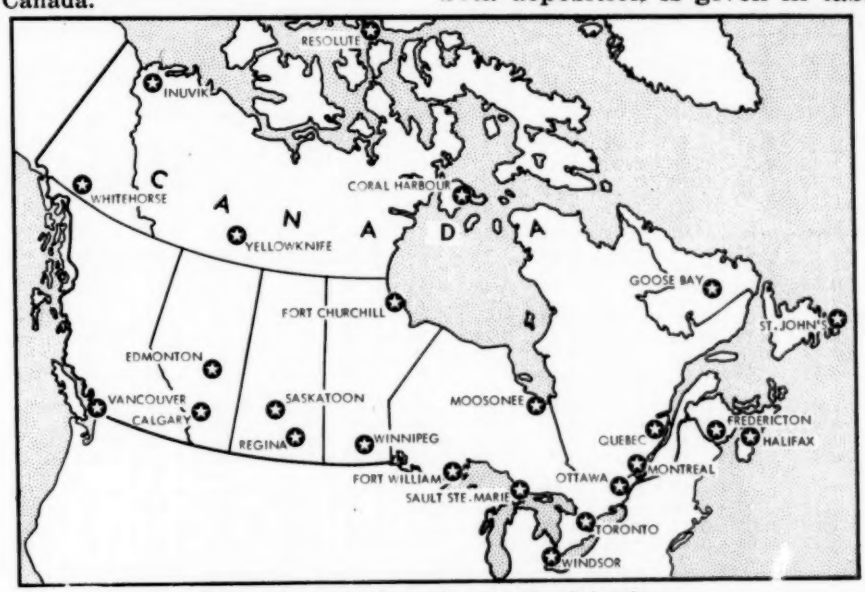

Figure 4. Canadian air and precipitation sampling stations

tion of selected radionuclides per unit area is given in table 4 for the period January through June 1965. A review and discussion of fallout levels in Canada during 1964 has been presented by Booth, *et al.* (*11*).

Table 3. Canadian gross beta activity in surface air and precipitation, June 1965

Station	Air surveillance				Precipitation measurements	
	Number of samples	Maximum (pCi/m³)	Minimum (pCi/m³)	Average (pCi/m³)	Average concentration, (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	3.2	0.1	1.1	240	40.8
Coral Harbour	30	0.2	0.0	0.1	369	0.9
Edmonton	30	2.4	0.1	0.7	114	21.7
Ft. Churchill	30	0.9	0.0	0.2	443	6.2
Ft. William	30	1.7	0.1	0.5	255	20.5
Fredericton	30	1.8	0.0	0.6	105	4.5
Goose Bay	30	2.1	0.0	0.3	160	22.9
Halifax	30	0.8	0.0	0.4	66	6.9
Inuvik	30	1.9	0.0	0.4	381	8.0
Montreal	30	3.6	0.1	0.8	415	7.7
Moosonee	30	1.5	0.0	0.3	398	12.7
Ottawa	30	2.1	0.0	0.7	567	10.3
Quebec	29	3.2	0.1	0.6	301	14.6
Regina	30	2.6	0.1	1.0	192	24.2
Resolute	27	0.2	0.0	0.1	52	1.4
St. John's, Nfld	28	2.5	0.0	0.5	137	9.5
Saskatoon	28	0.8	0.0	0.3	83	8.4
Sault Ste. Marie	25	1.5	0.1	0.5	196	17.6
Toronto	29	1.8	0.1	0.5	159	6.8
Vancouver	30	1.6	0.1	0.4	353	4.7
Whitehorse	30	1.9	0.0	0.3	324	4.7
Windsor	30	2.3	0.1	0.9	172	7.3
Winnipeg	30	2.8	0.1	0.6	288	17.3
Yellowknife	17	1.2	0.0	0.4	334	11.7
Network summary		3.6	0.0	0.5	254	12.1

Table 4. Radionuclide deposition (nCi/m²) in Canadian fallout, January–June 1965[a]

Station	Strontium-89		Strontium-90						Cesium-137						Zirconium-95		Barium-140	
	May	June	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June	May	June	May	June
Calgary	0.20	5.06	0.06	0.13	0.16	0.24	0.53	2.46	0.13	0.23	0.28	0.41	0.92	3.01	0.10	2.22	0.67	4.07
Coral Harbour	0.00	0.10	0.11	0.06	0.11	0.07	0.23	0.00	0.19	0.12	0.19	0.16	0.54	0.03				
Edmonton	0.97	2.48	0.17	0.15	0.06	0.30	0.98	1.05	0.22	0.23	0.13	0.56	1.74	1.65				
Ft. Churchill	0.00	0.80	0.06	0.15	0.03	0.14	0.29	0.40	0.10	0.10	0.13	0.23	0.65	0.60				
Ft. William	9.30	2.32	0.07	0.32	0.25	0.57	1.10	1.56	0.15	0.55	0.33	0.80	1.81	1.74				
Fredericton	0.56	1.42	0.21	0.20	0.06	0.44	0.55	0.77	0.33	0.52	0.16	0.68	1.10	1.20				
Goose Bay	0.10	2.48	0.29	0.16	0.19	0.10	0.36	1.51	0.26	0.27	0.22	0.65	0.59	2.00				
Halifax	0.96	1.17	0.60	0.24	0.18	0.62	0.62	0.43	1.72	0.62	0.48	0.76	1.16	0.64	0.12	0.22	1.72	0.87
Inuvik	0.00	0.80	0.06	0.03	0.11	0.16	0.28	0.41	0.16	0.11	0.19	0.20	0.45	0.75				
Montreal	0.99	0.76	0.26	0.24	0.12	0.39	0.61	0.36	0.42	0.44	0.21	0.69	0.98	0.67	1.45	0.58	3.20	0.69
Moosonee	1.95	1.83	0.09	0.04	0.04	0.17	0.84	0.51	0.15	0.08	0.12	0.46	1.34	1.05				
Ottawa	0.33	0.85	0.15	0.13	0.06	0.56	0.49	0.45	0.35	0.54	0.20	0.75	0.75	0.61				
Quebec	1.03	1.41	0.26	0.53	0.28	0.33	0.87	0.88	0.62	1.40	0.57	0.93	1.53	1.19				
Regina	1.39	2.03	0.04	0.12	0.14	0.29	0.76	1.58	0.11	0.25	0.25	0.58	1.49	1.94				
Resolute	0.00	0.24	0.06	0.32	0.11	0.00	0.05	0.00	0.15	0.50	0.20	0.00	0.10	NA				
St. John's, Nfld	0.35	1.25	0.48	0.27	0.63	0.70	0.61	0.63	0.96	0.35	1.12	1.07	0.93	0.88				
Saskatoon	1.23	1.61	0.04	0.05	0.07	0.15	0.55	1.00	0.12	0.07	0.18	0.36	1.30	0.74				
Sault Ste. Marie	0.57	1.99	0.24	0.14	0.06	0.62	1.07	0.89	0.61	0.73	0.23	1.20	1.56	1.30				
Toronto	0.33	0.57	0.49	0.45	0.30	0.77	0.50	0.37	0.97	0.69	0.50	1.39	0.96	0.57				
Vancouver	0.38	0.44	0.59	1.16	0.54	0.77	0.84	0.18	0.90	1.78	1.01	1.23	1.30	0.37	2.19	0.26	1.80	0.51
Whitehorse	0.00	0.38	0.04	0.02	0.07	0.07	0.11	0.15	0.07	0.04	0.14	0.16	0.22	0.32				
Windsor	3.20	0.78	0.47	0.28	0.51	0.73	0.81	0.31	1.06	0.40	0.80	1.18	1.30	0.37				
Winnipeg	2.73	2.08	0.03	0.12	0.07	0.61	1.41	1.09	0.13	0.18	0.09	0.91	2.28	1.54	3.40	1.19	9.84	2.27
Yellowknife	0.17	0.77	0.04	0.02	0.08	0.05	0.08	0.90	0.06	0.06	0.15	0.20	0.17	1.23				

[a] Samples from all stations are routinely analyzed for ^{89}Sr, ^{90}Sr, and ^{137}Cs; samples from five selected stations are regularly analyzed for ^{95}Zr and ^{140}Ba. Negligible results are not reported.
NA, no analysis.

4. Mexican Air Monitoring Program June 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*12-16*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new surveillance network. This network consists of 17 stations (see figure 5), 12 of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Figure 5. Fallout network sampling stations in Mexico

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- x 8-inch glass-fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radioactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated back to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during June 1965 are presented in table 5.

Table 5. Gross beta activity of airborne particulates, Mexico, June 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	4	0.3	0.1	0.2
Ciudad Juárez	15	6.5	0.1	0.9
Chihuahua	27	0.9	0.1	0.2
Ensenada	8	0.4	0.1	0.2
Guadalajara	4	<0.1	<0.1	<0.1
Guaymas	9	0.5	<0.1	0.2
La Paz	3	0.3	<0.1	0.2
Matamoros	2	0.3	0.2	0.2
Mazatlán	19	0.6	<0.1	0.3
Mérida	13	0.5	<0.1	0.1
México, D.F.	15	0.2	<0.1	<0.1
Nuevo Laredo	10	0.4	<0.1	0.2
San Luis Potosí	10	0.5	<0.1	0.3
Tampico	18	0.5	<0.1	0.1
Torréon	8	0.9	0.1	0.3
Tuxtla Gutiérrez*				
Veracruz	11	0.9	<0.1	0.2

* Station temporarily shut down.

5. Pan American Air Sampling Program June 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by five countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The five air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; and in Trinidad, West Indies, by the University of the West Indies.

The June 1965 air monitoring results from the five participating countries are given in table 6.

Table 6. Gross beta activity in surface air, June 1965 (concentrations in pCi/m³),

Sampling stations	Number of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	18	0.10	<0.10	<0.10
Caracas, Venezuela	19	0.55	<0.10	<0.14
Lima, Peru	21	0.10	<0.10	<0.10
Santiago, Chile	26	0.13	<0.10	<0.10
Trinidad, West Indies	18	0.49	<0.10	<0.20

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network June 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from 1 day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analysis.

Analytical procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry.[1] After the weekly samples are gamma scanned, samples from 2 consecutive weeks are composited and analyzed radiochemically to determine strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

Table 1. Analytical errors associated with determinations of radionuclides concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	less than 100	10	100 or greater	10
Barium-140	less than 100	10	100 or greater	10
Cesium-137	less than 100	10	100 or greater	10
Strontium-89	less than 50	5	50 or greater	10
Strontium-90	less than 20	2	20 or greater	10

[a] Two standard deviations

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, 10; barium–140, 10; and iodine–131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations [2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for June 1965 (actual reporting period is May 30 through June 26). Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. A modified averaging procedure has been used for iodine–131 and barium–140 since October 1963, when nondetectable concentrations of these radionuclides began to be considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations.

The distribution of monthly average strontium–90 concentrations as observed in pasteurized milk for January through June 1965 is presented in table 3. The maximum monthly average concentration of strontium–90 was 48 pCi/liter, observed at Minot, North Dakota. This level is within the lower half of Range II

[2] The conversion factor is 1.18 milligram, K/pCi^{40}K.

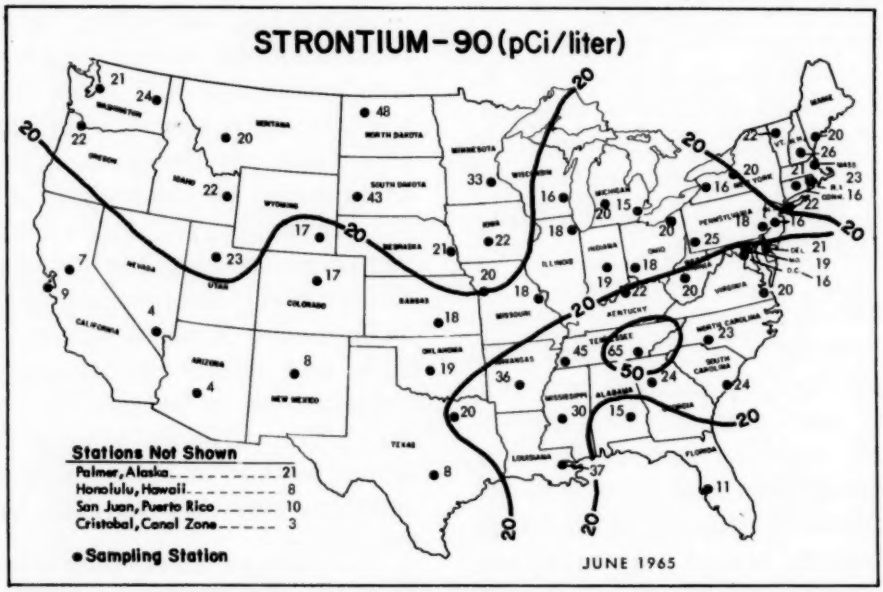

Figure 1. Strontium–90 concentrations in pasteurized milk, June 1965

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk, second quarter 1965 and June 1965 [a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		Second quarter	Average for June	Second quarter	Average for June	Second quarter	Average for June	Second quarter	Average for June	Second quarter	Average for June
Ala:	Montgomery	1.17	1.14	<5	5	18	15	55	50	0	0
Alaska:	Palmer	1.22	1.23	<5	<5	20	21	65	50	0	0
Ariz:	Phoenix	1.21	1.23	<5	<5	5	4	20	20	0	0
Ark:	Little Rock	1.15	1.15	5	10	38	36	70	70	10	20
Calif:	Sacramento	1.25	1.25	<5	<5	8	7	35	25	0	0
	San Francisco	1.26	1.27	<5	<5	11	9	35	20	0	0
C. Z:	Cristobal	1.10	1.08	<5	<5	4	3	35	30	0	0
Colo:	Denver	1.33	1.33	<5	<5	19	17	70	65	0	10
Conn:	Hartford	1.11	1.10	<5	<5	15	16	75	60	0	0
Del:	Wilmington	1.14	1.12	<5	5	19	21	70	65	0	10
D. C:	Washington	1.15	1.10	5	10	17	16	55	55	10	20
Fla:	Tampa	1.16	1.14	<5	<5	12	11	175	170	0	0
Ga:	Atlanta	1.15	1.16	<5	5	29	24	85	70	0	10
Hawaii:	Honolulu	1.23	1.27	<5	<5	10	8	55	45	0	0
Idaho:	Idaho Falls	1.27	1.30	<5	<5	20	22	95	90	10	20
Ill:	Chicago	1.13	1.11	<5	<5	17	18	75	50	10	20
Ind:	Indianapolis	1.15	1.12	5	10	19	19	55	40	10	40
Iowa:	Des Moines	1.26	1.26	10	20	23	22	55	40	20	40
Kans:	Wichita	1.25	1.22	<5	5	18	18	50	50	10	20
Ky:	Louisville	1.15	1.13	5	15	24	22	45	35	10	30
La:	New Orleans	1.20	1.18	5	15	42	37	80	70	10	20
Maine:	Portland	1.17	1.11	<5	5	21	20	125	100	0	10
Md:	Baltimore	1.14	1.12	5	10	19	19	60	55	10	20
Mass:	Boston	1.13	1.12	<5	5	22	21	125	90	0	0
Mich:	Detroit	1.13	1.11	<5	5	17	15	75	50	10	20
	Grand Rapids	1.16	1.13	<5	5	19	20	80	65	10	20
Minn:	Minneapolis	1.29	1.32	10	25	28	33	90	75	20	60
Miss:	Jackson	1.18	1.18	5	10	34	30	55	55	0	10
Mo:	Kansas City	1.25	1.28	10	25	22	20	45	40	30	60
	St. Louis	1.20	1.06	5	10	19	18	45	35	20	40
Mont:	Helena	1.28	1.22	<5	<5	20	19	95	75	10	0
Nebr:	Omaha	1.19	1.15	5	15	21	21	50	45	20	40
Nev:	Las Vegas	1.28	1.28	<5	5	7	4	40	30	10	20
N. H:	Manchester	1.15	1.13	<5	<5	25	26	150	125	0	0
N. J:	Trenton	1.11	1.10	<5	<5	16	16	70	55	0	0
N. Mex:	Albuquerque	1.23	1.17	<5	<5	11	10	35	20	0	0
N. Y:	Buffalo	1.10	1.10	<5	<5	17	16	95	55	0	0
	New York	1.11	1.10	<5	<5	21	22	90	60	0	10
	Syracuse	1.10	1.10	<5	<5	18	20	80	50	0	10
N. C:	Charlotte	1.20	1.18	5	10	27	23	65	60	0	10
N. Dak:	Minot	1.27	1.30	10	20	57	48	120	120	10	20
Ohio:	Cincinnati	1.13	1.12	<5	5	18	18	50	35	10	20
	Cleveland	1.13	1.10	5	10	20	20	75	55	10	20
Okla:	Oklahoma City	1.12	1.08	5	15	20	19	45	45	10	30
Ore:	Portland	1.30	1.28	<5	<5	24	22	90	85	0	0
Pa:	Philadelphia	1.13	1.12	<5	5	19	18	65	50	0	0
	Pittsburgh	1.14	1.12	5	10	25	25	95	70	10	20
P. R:	San Juan	1.12	1.11	<5	5	11	10	50	50	0	10
R. I:	Providence	1.12	1.12	<5	5	20	23	95	80	0	0
S. C:	Charleston	1.16	1.11	<5	5	27	24	100	85	0	10
S. Dak:	Rapid City	1.05	1.22	10	25	33	43	105	85	10	40
Tenn:	Chattanooga	1.19	1.18	5	10	30	29	65	60	0	10
	Memphis	1.15	1.16	5	15	26	25	45	45	10	20
Tex:	Austin	1.12	1.08	<5	5	8	8	25	30	0	10
	Dallas	1.17	1.14	5	10	20	20	45	40	0	10
Utah:	Salt Lake City	1.39	1.38	<5	<5	26	23	120	105	10	30
Vt:	Burlington	1.12	1.11	<5	<5	21	22	100	75	0	0
Va:	Norfolk	1.17	1.14	5	10	21	20	60	55	10	10
Wash:	Seattle	1.27	1.25	<5	<5	25	26	105	110	0	0
	Spokane	1.30	1.31	<5	<5	27	24	90	70	0	0
W. Va:	Charleston	1.12	1.10	10	15	20	20	40	30	10	20
Wis:	Milwaukee	1.19	1.18	<5	5	17	16	85	60	10	20
Wyo:	Laramie	1.23	1.20	5	10	17	17	70	65	10	30
Network average		1.18	1.17	<5	10	20.7	20	72	61	6	15

[a] All station second quarter averages and all but two station monthly averages for barium-lanthanum-140 were 0. The stations were Chicago and Indianapolis for which the monthly average was 10 pCi/liter.

defined by the Federal Radiation Council (20–200 pCi/liter). The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

The Network average cesium–137 concentration in milk for June 1965 was 61 pCi/liter as compared to 74 pCi/liter in May 1965. The maximum monthly average concentration in pasteurized milk was 170 pCi/liter, observed at Tampa, Florida. The distribution of monthly average cesium–137 concentrations in milk for January through June 1965 is presented in table 4.

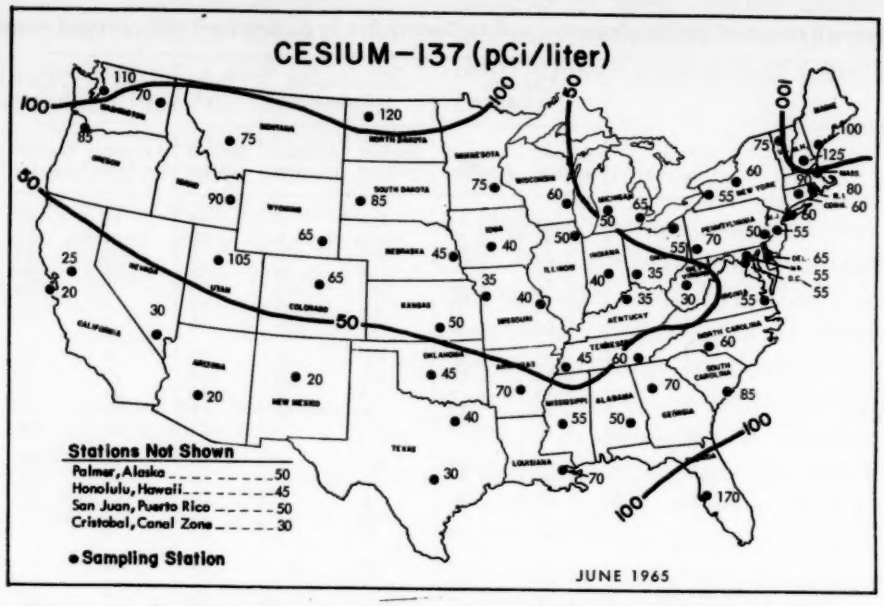

Figure 2. Cesium–137 concentrations in pasteurized milk, June 1965

The decrease in radionuclide concentrations in milk observed during January through June 1965 can be expected to continue in the absence of atmospheric nuclear testing. This trend is from March 1960 through 1964 (*2,3*).

During June 1965, iodine–131 was observed in weekly milk samples at 48 sampling stations (table 5). The maximum concentration observed was 130 pCi/liter on June 4, 1965. The levels of iodine–131 observed were

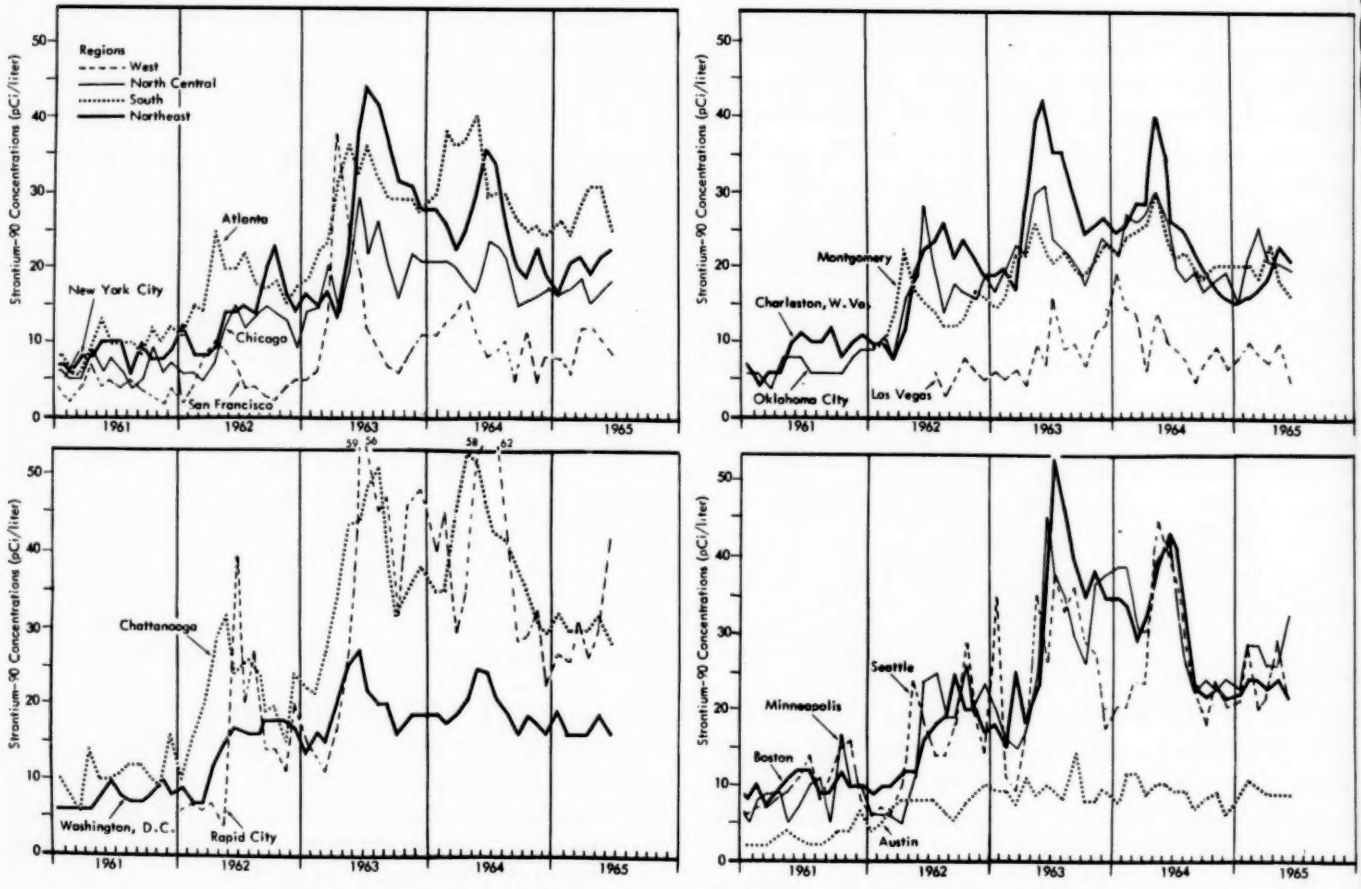

Figure 3. Strontium–90 concentrations in pasteurized milk, 1961–June 1965

such that 42 stations exhibited monthly averages greater than the detection limit of 10 pCi/liter. The highest monthly average, 60 pCi/liter observed in Kansas City, Missouri, was well within Range II as defined by the Federal Radiation Council (10–100 pCi/liter). The presence of iodine–131 in pasteurized milk during June 1965 is presumed a consequence of the mainland China atmospheric nuclear test on May 14, 1965.

Table 3. Frequency distribution of strontium-90 concentrations in milk at PMN stations, January–June 1965, and June 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	Jan	Feb	Mar	Apr	May	Jun	Jun
Under 10	6	3	5	5	4	7	4
10–19	32	31	29	23	26	21	6
20–29	19	22	21	27	25	29	23
30–39	4	5	6	5	5	4	17
40–49	1	2	1	2	2	2	10
50–59	1	0	1	0	0	0	2
60–69	0	0	0	1	1	0	10
70–79	0	0	0	0	0	0	1

Table 4. Frequency distribution of cesium-137 concentrations in milk at PMN stations, January–June 1965, and June 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	Jan	Feb	Mar	Apr	May	Jun	Jun
Under 50	11	8	9	7	17	19	1
50–99	38	38	36	35	31	38	19
100–149	12	15	16	18	13	5	24
150–199	2	2	2	3	2	1	13
200–249	0	0	0	0	0	0	4
250–299	0	0	0	0	0	0	2

Table 5. Occurrence of iodine-131 in Pasteurized Milk Network, June 1965

(Concentration in pCi/liter)

Sampling location		June, 1965																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ala:	Montgomery	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ark:	Little Rock	30	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Colo:	Denver	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	30	---	---	---	---	---
Del:	Wilmington	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
D. C:	Washington	---	---	40	---	---	---	---	---	---	---	20	---	---	---	---	---	30	---	---	---	---	---	---	---	---	---	---	---	---
Fla:	Tampa	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	10	---	---	---	---	---	---	---
Ga:	Atlanta	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Idaho:	Idaho Falls	40	---	---	---	---	---	---	---	---	---	---	---	---	40	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ill:	Chicago	50	---	---	---	---	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ind:	Indianapolis	80	---	---	---	---	---	40	---	---	---	---	---	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Iowa:	Des Moines	---	---	100	---	---	---	---	50	60	---	70	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Kans:	Wichita	---	---	---	---	---	---	30	---	---	---	---	---	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ky:	Louisville	60	---	---	---	---	---	40	---	---	---	---	---	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
La:	New Orleans	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	20	---	---	---	---	---
Me:	Portland	20	---	---	---	---	---	---	---	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Md:	Baltimore	30	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	10	---	---	---	---	---	---	---
Mass:	Boston	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Mich:	Detroit	60	---	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Grand Rapids	40	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Minn:	Minneapolis	80	---	---	---	---	---	---	---	60	---	---	---	---	---	60	---	---	---	---	---	---	40	---	---	---	---	---	---	---
Miss:	Jackson	---	---	---	---	---	---	60	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Mo:	Kansas City	---	---	---	130	---	---	60	---	60	---	50	---	---	---	---	---	---	60	---	---	---	---	---	---	---	---	---	---	---
	St. Louis	---	---	40	---	---	---	---	---	---	60	---	---	---	---	---	---	50	---	---	---	---	---	---	20	---	---	---	---	---
Nebr:	Omaha	---	---	---	70	---	---	---	---	---	---	40	---	---	---	---	---	---	30	---	---	---	---	---	20	---	---	---	---	---
Nev:	Las Vegas	---	---	---	---	---	---	---	---	---	---	---	---	---	---	50	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N. H:	Manchester	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N. J:	Trenton	---	---	---	---	---	---	---	---	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N. Y:	New York	20	---	---	---	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Syracuse	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
N. C:	Charlotte	20	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N. Dak:	Minot	---	---	---	---	---	---	60	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ohio:	Cincinnati	---	---	40	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
	Cleveland	---	---	---	50	---	---	---	---	---	---	30	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---
Okla:	Oklahoma City	---	40	---	---	---	---	---	---	40	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Pa:	Philadelphia	---	---	---	10	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Pittsburgh	40	---	---	---	---	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
P. R:	San Juan	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---
S. C:	Charleston	10	---	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	---
S. Dak:	Rapid City	---	---	---	---	---	---	60	---	---	---	---	---	---	50	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Tenn:	Chattanooga	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
	Memphis	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---
Tex:	Austin	---	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---
	Dallas	---	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Utah:	Salt Lake City	50	---	---	---	---	---	---	---	---	---	---	---	---	40	---	---	---	---	---	---	30	---	---	---	---	---	---	---	---
Va:	Norfolk	---	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---
W. Va:	Charleston	---	---	---	40	---	---	---	---	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---
Wis:	Milwaukee	50	---	---	---	---	---	---	30	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Wyo:	Laramie	---	---	---	40	---	---	---	---	50	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---

2. Oklahoma Milk Network March–July 1965

Oklahoma State Department of Health [3]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 4. There are ten milksheds in the State of Oklahoma. The five which were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) were selected on the basis of the size and location of their milksheds. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap will assist in locating any small areas of production where the iodine–131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk processing plant in the milkshed, and while the milkshed for that particular processing plant may not coincide exactly with that shown in figure 4, and coincidence is satisfactory for surveillance purposes.

Sampling

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine–131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about four hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

Analytical method

The method of analysis is similar to that recently published by the U. S. Public Health Service (*4*) but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory and has not been published to date.

The sampling stations are supplied with plastic cartridges containing 10 ml of Dowex 1X8, 50–100 mesh anion exchange resin. On the sampling date, one gallon of pasteurized whole milk is passed through the cartridge,

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[3] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, Chief Engineer.

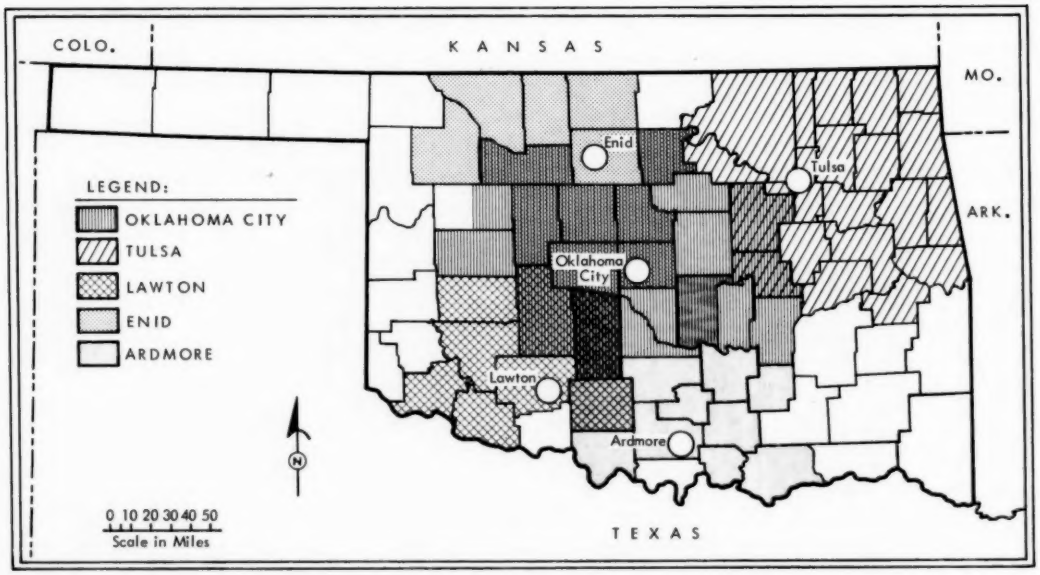

Figure 4. Milksheds of the five Oklahoma dairies used as sampling locations

the residual milk is washed from the resin with distilled water, and the cartridge is mailed to the Radiological Health Laboratory where it is counted for 100 minutes in a 2- x 2-inch well type, thallium-activated sodium iodide crystal. The gamma energy is analyzed in a 400-channel analyzer. The results are corrected to noon of the sampling date. The minimum detectable concentration is 0.9 pCi/liter (3 standard deviations of background).

Results and discussion

Table 6 gives the concentrations of iodine–131 found in Oklahoma milk samples collected from the inception of the program through July 25, 1965.

The observed iodine–131 concentrations clearly reflect the arrival and subsequent decrease in fresh fission products which are presumed to have resulted from the second Chinese atmospheric nuclear test of May 14, 1965.

Table 6. Concentration of iodine-131 in Oklahoma milk, March to July, 1965

(Concentrations in pCi/liter)

Date	Sampling location				
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore
March 15	<1	<1	<1	<1	<1
22	<1	<1	<1	<1	<1
29	<1	<1	<1	<1	<1
April 5	IF	IF	IF	IF	IF
12	<1	<1	<1	<1	<1
19	<1	<1	<1	<1	NS
26	<1	<1	<1	<1	<1
May 3	<1	<1	NS	<1	<1
10	<1	<1	<1	<1	<1
17	<1	NS	<1	<1	NS
24	<1	<1	<1	<1	<1
31	<1	NS	NS	<1	3.9
June 7	37.4	41.6	24.6	35.4	32.8
14	16.7	20.6	16.9	15.8	14.0
21	5.1	7.5	4.9	8.3	NS
28	3.4	3.3	3.3	2.0	2.6
July 5	<1	NS	<1	<1	NS
12	<1	<1	<1	<1	NS
19	<1	<1	<1	<1	<1
25	<1	<1	<1	<1	<1

Key to Symbols: NS, no sample collected.
IF, instrument failure.

3. Texas Milk Network January–March 1965

Texas State Department of Health [4]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "stand-by" stations have been supplied sample containers and shipping instructions and can be activated immediately, if needed. The "active" and "stand-by" station locations, shown in figure 5, were chosen to give maximum geographical and population coverage. The monthly grab samples are taken from tank trucks at the processing plants.

Analytical methods

Samples are routinely analyzed for iodine–131, barium–140, cesium–137, potassium–40, strontium–89, and strontium–90. The gamma-emitting radionuclides are analyzed using a 4- x 4-inch sodium iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3½ liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95 percent confidence

Figure 5. Texas milk sampling stations

level are 10 pCi/liter. Calcium determinations are not made.

Strontium–89 and strontium–90 are analyzed by a chemical separation technique using ion exchange columns (*5*). Prepared samples are counted for 100 minutes in a low-background beta counter.

Results

Potassium–40, strontium–90, and cesium–137 results by station and month for January

[4] Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale Mchard, Head, and Mr. Robert Craig, Assistant Engineer.

and March are presented in table 7. During this time, the strontium–89 concentration was below the limit of detectability (5 pCi/liter). Iodine–131 and barium–140 were also below their limits of detectability (10 pCi/liter).

Network average concentrations for April 1964 throughMarch 1965 are shown in figure 6. Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*6*).

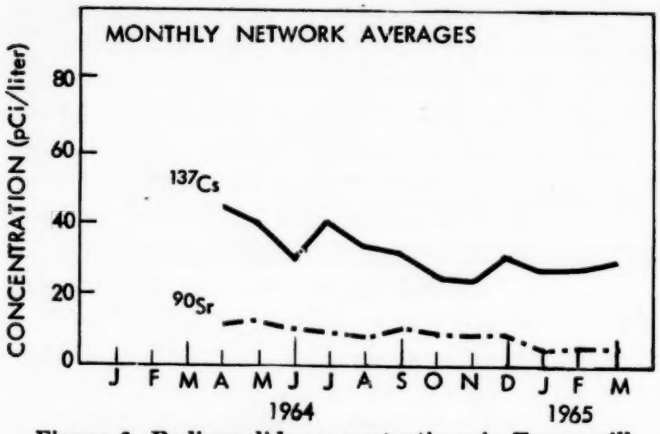

Figure 6. Radionuclide concentrations in Texas milk network, April 1964–March 1965

Table 7. Radionuclide concentrations in Texas Milk Network, January–March 1965

Sampling location	Potassium-40 (pCi/liter)		
	January	February	March
Austin	1280	1280	1350
Dallas	* NS	NS	NS
El Paso	1290	1300	1440
Harlingen	1410	1350	1370
Houston	1390	1370	1220
Lubbock	1340	1300	1330
Average	1342	1320	1342

Sampling location	Strontium-90 (pCi/liter)		
	January	February	March
Austin	4	7	6
Dallas	NS	NS	NS
El Paso	3	3	4
Harlingen	5	7	5
Houston	8	5	12
Lubbock	7	6	5
Average	5	6	6

Sampling location	Cesium-137 (pCi/liter)		
	January	February	March
Austin	20	40	30
Dallas	NS	NS	NS
El Paso	30	20	25
Harlingen	30	15	15
Houston	40	50	60
Lubbock	25	20	20
Average	29	29	30

* NS, no sample collected.

4. Canadian Milk Network [5] June 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative monthly composite samples of milk consumed can be obtained, and milk sampling locations (figure 7) can be chosen in the same areas as the air and precipitation stations.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales.

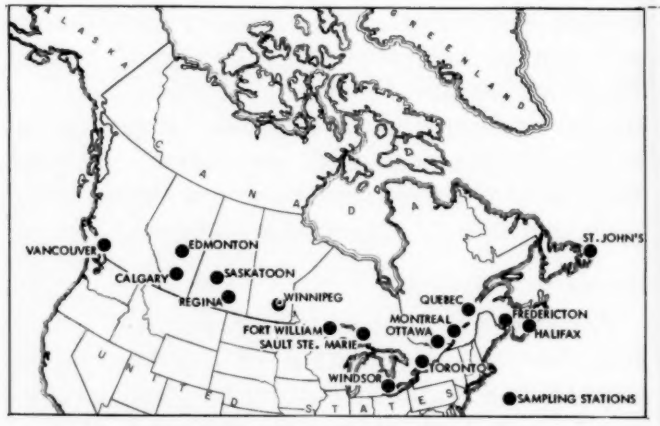

Figure 7. Canadian milk sampling stations

[5] This report was prepared from information and data in the July 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

in most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–89, strontium–90, cesium–137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine–131 (*7*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle furnace at 450°C., and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potasium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the gamma spectrometric determination of cesium–137 no recovery factor is involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

Table 8. Total error for various radionuclide concentrations in milk [a]

Radionuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	25%	20%	15%
Strontium-90	15%	10%	10%
Iodine-131	50%	20%	10%
Cesium-137	60%	20%	10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 9 presents monthly averages of strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

Table 9. Stable elements and radionuclides in Canadian whole milk, June 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.05	1.6	23.6	30.9	94
Edmonton	1.06	1.6	29.6	24.2	83
Ft. William	1.12	1.7	27.8	37.7	100
Fredericton	1.12	1.6	11.1	34.9	126
Halifax	1.08	1.6	19.6	36.7	119
Montreal	1.13	1.6	10.1	20.9	71
Ottawa	1.12	1.6	9.1	17.7	81
Quebec	1.12	1.6	12.7	36.8	130
Regina	1.12	1.5	20.1	31.2	70
St. John's, Nfld	1.13	1.4	9.8	53.9	204
Saskatoon	1.11	1.5	12.3	26.5	60
Sault Ste. Marie	1.11	1.6	9.2	36.1	106
Toronto	1.09	1.6	6.1	12.1	43
Vancouver	1.12	1.6	8.1	33.1	173
Windsor	1.08	1.6	12.1	12.4	42
Winnipeg	1.12	1.6	12.3	26.2	77
Average	1.11	1.6	14.6	29.5	99

5. Pan American Milk Sampling Program June 1965

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963, the program was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, additional stations were established in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde, and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the Condensery in Kingston. All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma scintillation spectrometry. Strontium–89, strontium–90 and barium–140 are determined radiochemically (*5*). Analytical errors are discused in the "Analytical Procedures, Pasteurized Milk Network" (see page 535).

Data presentation

Table 10 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations. The monthly average of iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

Table 10. Stable element and radionuclide concentrations in milk, PAHO, June 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone: Cristobal	1.08	1.5	<5	4	30
Jamaica: Kingston	1.16	1.42	<5	12	120
Mandeville	NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico: San Juan	1.11	1.5	<5	10	50
Venezuela: Caracas	1.15	1.38	<5	5	20

Key to symbols: NS, no sample collected.
Blanks indicate no report received.

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, JUNE 1964–JUNE 1965

Division of Radiological Health
Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3,4*).

Total dietary intake is of prime interest, and since the intake-via-milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 grams of calcium per liter in PMN samples and a 1.0 grams daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows:

[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (*6*).

Table 1. Average radionuclide concentrations in milk for the twelve month periods,[a] June 1964–May 1965 and July 1964–June 1965

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)	
		June 1964–May 1965	July 1964–June 1965	June 1964–May 1965	July 1964–June 1965	June 1964–May 1965	July 1964–June 1965	June 1964–May 1965	July 1964–June 1965
Ala:	Montgomery	3	3	20	19	0	0	58	56
Alaska:	Palmer	3	3	19	18	1	1	85	78
Ariz:	Phoenix	3	3	5	5	0	0	24	24
Ark:	Little Rock	3	4	37	36	1	2	74	70
Calif:	Sacramento	3	3	7	7	1	1	33	31
	San Francisco	3	3	8	8	0	0	35	32
C. Z:	Cristobal	3	3	5	5	0	0	45	44
Colo:	Denver	3	3	19	18	0	1	80	77
Conn:	Hartford	3	3	18	18	0	0	98	91
Del:	Wilmington	3	3	19	19	1	2	81	76
D. C:	Washington	3	3	18	17	1	2	59	56
Fla:	Tampa	3	3	14	14	0	0	208	200
Ga:	Atlanta	3	3	27	27	0	1	96	92
Hawaii:	Honolulu	3	3	11	11	0	0	70	66
Idaho:	Idaho Falls	3	3	22	21	0	2	108	100
Ill:	Chicago	3	3	18	17	0	2	86	81
Ind:	Indianapolis	3	3	18	17	1	4	70	65
Iowa:	Des Moines	3	4	23	22	3	6	64	60
Kans:	Wichita	3	3	19	18	0	2	50	48
Ky:	Louisville	3	4	25	24	0	2	54	50
La:	New Orleans	4	5	44	43	0	2	94	88
Maine:	Portland	3	3	25	24	1	2	152	144
Md:	Baltimore	3	3	20	19	0	2	65	61
Mass:	Boston	3	3	26	25	0	0	154	142
Mich:	Detroit	3	3	17	16	2	3	85	81
	Grand Rapids	3	3	19	19	1	2	94	90
Minn:	Minneapolis	4	6	27	26	1	6	99	92
Miss:	Jackson	3	3	35	34	0	1	67	64
Mo:	Kansas City	3	5	23	23	4	8	54	50
	St. Louis	3	3	19	18	1	4	54	49
Mont:	Helena	3	3	19	18	3	3	103	97
Nebr:	Omaha	3	3	22	21	1	4	63	60
Nev:	Las Vegas	3	3	8	7	1	2	50	45
N. H:	Manchester	3	3	26	25	1	1	172	164
N. J:	Trenton	3	3	17	16	1	1	82	77
N. Mex:	Albuquerque	2	2	10	10	1	1	45	42
N. Y:	Buffalo	3	3	18	17	0	0	107	100
	New York	3	3	22	21	1	2	110	102
	Syracuse[b]	3	3	16	16	0	1	94	86
N. C:	Charlotte	3	3	34	32	0	1	79	74
N. Dak:	Minot	5	6	51	49	0	2	129	124
Ohio:	Cincinnati	3	3	18	18	0	2	64	59
	Cleveland	3	3	19	18	1	2	89	82
Okla:	Oklahoma City	3	4	20	19	0	2	51	49
Ore:	Portland	4	3	25	24	0	0	121	111
Pa:	Philadelphia	3	3	18	17	0	0	79	74
	Pittsburgh	3	3	27	25	0	2	110	101
P. R:	San Juan	3	3	12	11	0	1	58	56
R. I:	Providence	3	3	20	20	0	0	116	108
S. C:	Charleston	3	3	30	29	0	1	100	98
S. Dak:	Rapid City	4	5	34	33	0	3	126	119
Tenn:	Chattanooga	3	4	34	33	0	1	76	71
	Memphis	3	3	28	26	0	2	48	46
Tex:	Austin	3	3	8	8	0	1	31	29
	Dallas	3	3	18	18	0	1	44	42
Utah:	Salt Lake City	3	3	24	23	0	2	131	126
Vt:	Burlington	3	3	23	22	2	2	125	118
Va:	Norfolk	3	4	17	16	1	2	68	64
Wash:	Seattle	4	3	25	24	0	0	127	115
	Spokane	3	3	26	25	0	0	110	104
W. Va:	Charleston	3	4	20	19	1	2	49	45
Wis:	Milwaukee	3	3	15	15	2	3	96	90
Wyo:	Laramie	4	3	17	16	0	2	82	77
Network average		3	3	21	20	1	2	85	80

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <2 pCi/liter.
[b] Annual averages were computed on basis of 48 weekly averages.

results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous 12-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

[2] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter for individual samples are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

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RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES JANUARY–MARCH 1965

Division of Radiological Health Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially the program was conducted at eight institutions; as of January 1965, its scope had increased to 50 boarding schools or institutions, distributed as shown in figure 1. These institutions range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (with the exception of those at Los Angeles, California; Fargo, North Dakota; Columbia, Mississippi; and Carson City, Nevada) is located in a community from which the PHS Pasteurized Milk Network (PMN) collects samples. Special milk samples are collected from two institutions recently added to the network at Wrentham, Massachusetts, and Sioux Falls, South Dakota; these are not communities sampled by the PMN. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

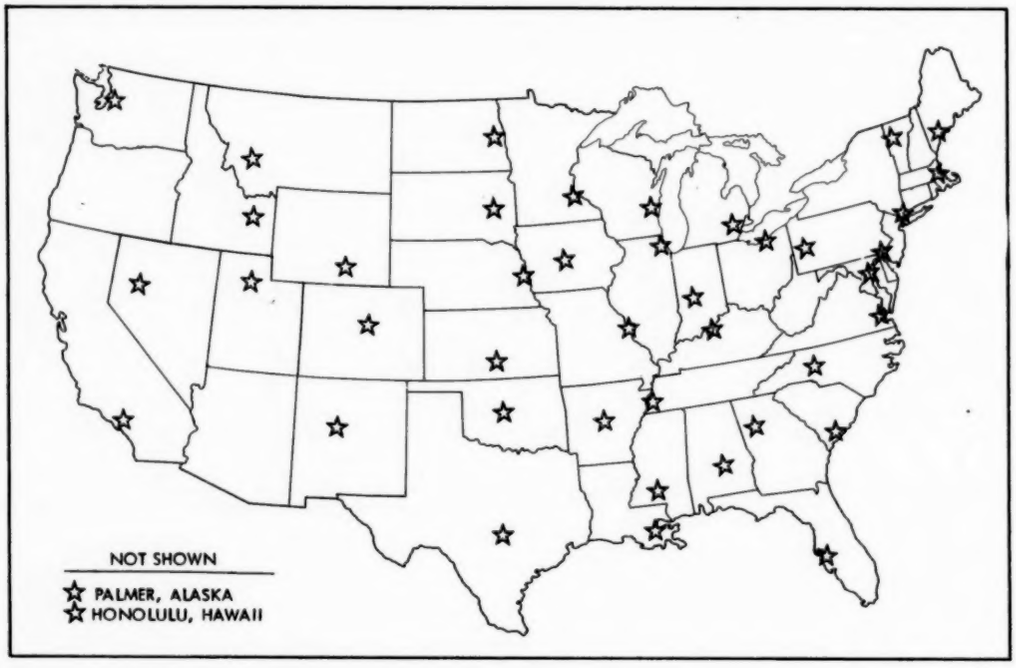

Figure 1. Institutional diet sampling locations

Table 1. Institutional diet analytical results, all schools, first quarter 1965

Location of institution	Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala: Montgomery	Jan	0.5	1.2	<5	11	45	NA
	Feb	0.6	1.2	<5	14	40	NA
	Mar	0.5	1.3	<5	11	45	NA
Alaska: Palmer	Jan	0.6	1.5	<5	15	100	0.6
	Feb	0.4	1.1	<5	8	80	0.5
	Mar	0.5	1.4	<5	17	60	NA
Ariz: Phoenix	Jan	0.7	1.7	<5	18	75	0.9
	Feb	0.8	1.9	<5	28	100	0.7
	Mar	0.7	1.5	<5	20	80	0.7
Ark: Little Rock	Jan	0.7	1.2	<5	20	50	NA
	Feb	0.7	1.2	<5	20	45	NA
	Mar	0.6	1.5	<5	22	40	NA
Calif: Los Angeles	Jan	0.5	1.6	<5	8	35	1.3
	Feb	0.8	1.9	<5	17	55	NA
	Mar	0.8	1.5	<5	13	20	0.7
Colo: Denver	Jan	0.7	1.4	<5	18	35	0.6
	Feb	0.5	1.6	<5	20	45	0.6
	Mar	0.7	1.4	<5	19	40	0.8
Conn: Hartford	Jan	0.7	1.7	<5	12	95	0.5
	Feb	0.7	1.7	<5	14	90	0.5
	Mar	0.6	1.6	<5	11	65	0.5
Del: Wilmington	Jan	0.8	1.8	<5	12	60	0.6
	Feb	0.8	1.8	<5	12	80	1.0
	Mar	0.8	1.7	<5	14	80	0.5
Fla: Tampa	Jan	0.7	1.4	<5	17	110	NA
	Feb	0.6	1.8	<5	8	105	NA
	Mar	0.8	1.4	<5	12	75	NA
Ga: Atlanta	Jan	0.5	1.6	<5	16	65	NA
	Feb	0.7	1.9	<5	19	70	NA
	Mar	0.7	1.7	<5	19	70	NA
Hawaii: Honolulu	Jan	0.5	1.2	<5	9	65	0.4
	Feb	0.4	1.0	<5	16	40	0.6
	Mar	0.5	1.0	<5	14	30	0.6
Idaho: Idaho Falls	Jan	0.6	1.4	<5	16	80	0.5
	Feb	0.6	1.7	<5	36	140	0.4
	Mar	0.7	1.6	<5	25	125	0.6
Ill: Chicago	Jan	0.8	1.6	<5	12	85	0.6
	Feb	0.8	1.5	<5	15	80	0.8
	Mar	0.8	1.6	<5	14	85	0.5
Ind: Indianapolis	Jan	0.7	1.5	<5	11	60	0.4
	Feb	0.9	1.5	<5	14	70	0.5
	Mar	0.7	1.6	<5	11	70	0.6
Iowa: Des Moines	Jan	0.7	1.8	<5	13	60	NA
	Feb	0.7	1.6	<5	13	60	NA
	Mar	0.7	1.6	<5	14	50	NA
Kans: Wichita	Jan	0.7	1.6	20	15	45	NA
	Feb	0.8	1.8	<5	16	50	NA
	Mar	0.8	1.7	<5	16	50	NA
Ky: Louisville	Jan	0.9	1.8	<5	19	50	NA
	Feb	0.7	1.5	<5	19	40	NA
	Mar	0.7	1.4	<5	16	35	NA
La: New Orleans	Jan	0.6	1.4	<5	17	100	NA
	Feb	0.7	1.5	<5	13	55	NA
	Mar	0.7	1.5	<5	19	60	NA
Maine: Portland	Jan	0.7	1.6	<5	17	100	0.5
	Feb	0.8	1.3	<5	13	85	0.6
	Mar	0.8	1.5	<5	17	95	0.5
Md: Baltimore	Jan	0.6	1.2	<5	15	40	NA
	Feb	0.6	1.0	<5	14	50	NA
	Mar	0.6	1.4	<5	14	50	NA
Mass: Boston A [a]	Jan	0.8	1.8	<5	19	115	0.5
	Feb	0.6	1.4	<5	12	80	0.4
	Mar	0.8	1.6	<5	18	105	0.7
Boston B [a]	Jan	0.6	1.6	<5	11	60	0.7
	Feb	0.6	1.4	<5	10	40	0.6
	Mar	0.6	1.3	<5	10	50	0.4
Mich: Detroit	Jan	0.8	1.7	<5	13	70	0.6
	Feb	0.8	1.5	<5	13	65	0.6
	Mar	0.8	1.6	<5	12	85	0.8
Minn: Minneapolis	Jan	NS	NS	NS	NS	NS	NS
	Feb	0.7	1.6	<5	53	65	0.7
	Mar	0.8	1.7	<5	38	80	0.4
Miss: Columbia	Jan	0.9	1.4	10	26	75	NA
	Feb	0.8	1.6	<5	18	70	NA
	Mar	0.8	1.4	<5	22	70	NA
Mo: St. Louis	Jan	0.7	1.4	<5	38	45	1.4
	Feb	0.7	1.6	<5	22	55	0.6
	Mar	0.7	1.7	<5	27	80	0.6
Mont: Helena	Jan	0.5	1.4	<5	14	70	0.7
	Feb	0.5	1.3	<5	21	70	0.4
	Mar	0.5	1.1	<5	16	60	0.4
Nebr: Omaha	Jan	0.8	1.5	<5	19	35	0.8
	Feb	0.8	1.4	<5	25	55	NA
	Mar	0.8	1.8	<5	21	55	1.1
Nev: Carson City	Jan	0.8	1.4	<5	11	40	1.1
	Feb	1.3	1.8	<5	46	40	1.6
	Mar	0.6	1.7	<5	25	40	0.6
N. J: Trenton	Jan	0.7	1.4	<5	11	60	1.3
	Feb	0.7	1.5	<5	12	65	0.7
	Mar	0.5	1.5	<5	10	70	1.5
N. Mex: Albuquerque	Jan	0.8	1.6	<5	9	25	0.7
	Feb	0.7	1.5	<5	13	35	0.7
	Mar	0.8	1.8	<5	10	30	0.9

Table 1. Institutional diet analytical results, all schools, first quarter 1965—Continued

Location of institution	Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
N. Y: New York	Jan	0.6	1.7	<5	14	90	0.8
	Feb	0.8	1.6	<5	16	70	1.0
	Mar	0.7	1.5	<5	12	65	1.0
N. C: Charlotte	Jan	0.6	1.2	<5	14	50	NA
	Feb	0.6	1.2	<5	19	40	NA
	Mar	0.6	1.0	<5	14	35	NA
N. Dak: Fargo	Jan	0.7	1.7	<5	15	95	0.5
	Feb	0.8	1.7	<5	11	70	0.5
	Mar	0.8	1.8	<5	13	65	1.2
Ohio: Cleveland	Jan	0.8	1.7	<5	12	85	0.4
	Feb	0.7	1.7	<5	10	70	0.8
	Mar	0.7	1.6	<5	13	70	0.8
Okla: Oklahoma City	Jan	0.8	1.7	<5	16	45	NA
	Feb	0.6	1.6	<5	11	35	NA
	Mar	0.7	1.7	<5	14	40	NA
Ore: Portland	Jan	0.6	1.7	<5	16	30	0.9
	Feb	0.5	1.5	<5	24	45	0.5
	Mar	0.5	1.5	<5	10	40	0.6
Pa: Pittsburgh	Jan	0.6	1.4	<5	15	70	0.5
	Feb	0.6	1.7	<5	19	75	0.8
	Mar	0.6	1.3	<5	15	60	0.7
R. I: Providence	Jan	0.7	1.5	<5	15	80	0.5
	Feb	0.8	1.5	<5	12	75	0.5
	Mar	NS	NS	NS	NS	NS	NS
S. C: Charleston	Jan	0.9	1.5	10	25	75	NA
	Feb	0.6	1.4	<5	14	60	NA
	Mar	0.7	1.5	<5	16	70	NA
S. Dak: Sioux Falls	Jan	0.9	1.7	<5	19	95	0.7
	Feb	0.8	1.5	<5	22	75	0.7
	Mar	0.7	1.7	<5	13	85	0.7
Tenn: Memphis	Jan	0.6	1.2	<5	16	40	NA
	Feb	0.6	1.5	<5	13	35	NA
	Mar	0.7	1.5	<5	14	40	NA
Tex: Austin	Jan	0.4	1.1	<5	8	20	NA
	Feb	0.5	1.0	<5	8	30	NA
	Mar	0.5	1.2	<5	6	30	NA
Utah: Salt Lake City	Jan	0.7	1.7	<5	9	75	0.5
	Feb	0.6	1.4	<5	14	60	0.4
	Mar	0.5	1.7	<5	16	65	0.6
Vt: Burlington	Jan	0.6	1.7	<5	14	80	0.5
	Feb	0.6	1.7	<5	15	90	0.5
	Mar	0.6	1.7	<5	14	90	0.4
Va: Norfolk	Jan	0.5	1.2	<5	17	45	NA
	Feb	0.5	1.1	<5	15	40	NA
	Mar	0.5	1.4	<5	14	40	NA
Wash: Seattle	Jan	0.8	1.4	<5	36	105	0.5
	Feb	0.7	1.1	<5	18	70	1.3
	Mar	0.6	1.4	<5	20	80	0.6
W. Va: Charleston	Jan	0.7	1.6	10	22	65	NA
	Feb	0.7	1.8	<5	17	70	NA
	Mar	0.8	1.9	<5	16	50	NA
Wis: Milwaukee	Jan	0.5	1.7	<5	9	65	0.9
	Feb	0.7	1.6	<5	10	80	0.7
	Mar	0.7	1.5	<5	11	60	0.5
Wyo: Laramie	Jan	0.7	2.0	<5	12	65	1.9
	Feb	0.8	1.4	<5	16	45	0.9
	Mar	0.7	1.5	<5	14	55	0.7
Institutional averages	Jan	0.7	1.5	<5	16	65	0.7
	Feb	0.7	1.5	<5	17	65	0.7
	Mar	0.7	1.5	<5	16	60	0.7

[a] "A" and "B" denote two separate institutions in Boston.
Key to symbols:
NA, no analysis.
NS, no samples.

Sampling procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vagas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The sample for each day is packaged in three parts: (1) solid food and semisolid food minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee, and tea. Drinking

Table 2. Institutional diet daily intakes, teenage boys, first quarter 1965

Location of institution	Age (yrs)	Month (1965)	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala: Montgomery	15–17	Jan	2.42	1.2	2.9	5	27	110	NA
	15–17	Feb	2.39	1.4	2.9	5	33	95	NA
	15–17	Mar	2.43	1.2	3.2	5	27	110	NA
Hawaii: Honolulu	14–16	Jan	1.40	0.7	1.7	5	13	90	0.6
	14–17	Feb	1.70	0.7	1.7	5	27	70	1.0
	15–19	Mar	1.87	0.9	1.9	5	26	55	1.1
Idaho: Idaho Falls	17	Jan	1.51	0.9	2.1	5	24	120	0.8
	15	Feb	2.04	1.2	3.5	5	73	285	0.8
	17	Mar	1.87	1.3	3.0	5	47	235	1.1
Iowa: Des Moines	14–16	Jan	2.66	1.9	4.8	5	35	160	NA
	15–16	Feb	3.16	2.2	5.1	10	41	190	NA
	15–16	Mar	2.90	2.0	4.6	5	41	145	NA
Ky: Louisville	15–17	Jan	2.46	2.2	4.4	5	47	125	NA
	15–16	Feb	1.81	1.3	2.7	5	34	70	NA
	15–17	Mar	2.14	1.5	3.0	5	34	75	NA
Maine: Portland	14	Jan	2.30	1.6	3.7	5	39	230	1.2
	14	Feb	2.39	1.9	3.1	5	31	205	1.4
	14	Mar	2.21	1.8	3.3	5	38	210	1.1
Minn: Minneapolis	NS	Jan	NS	NS	NS	NS	NS	NS	NS
	14–16	Feb	2.20	1.5	3.5	5	117	145	1.5
	14–15	Mar	2.12	1.7	3.6	5	81	170	0.8
Miss: Columbia	15–17	Jan	2.10	1.9	2.9	20	55	160	NA
	15–17	Feb	3.01	2.4	4.8	10	54	210	NA
	15–17	Mar	2.00	1.6	2.8	5	44	140	NA
Mo: St. Louis	15–17	Jan	1.22	0.8	1.7	5	46	55	1.7
	15–17	Feb	1.81	1.3	2.9	5	40	100	1.1
	15–17	Mar	2.52	1.8	4.3	5	68	200	1.5
Nebr: Omaha	15–18	Jan	1.50	1.2	2.2	5	28	50	1.2
	15–17	Feb	1.72	1.4	2.4	5	43	95	NA
	16–17	Mar	1.78	1.4	3.2	5	37	100	2.0
N. J: Trenton	15–17	Jan	2.31	1.6	3.2	5	25	140	3.0
	15–17	Feb	2.25	1.6	3.4	5	27	145	1.6
	15–17	Mar	2.40	1.2	3.6	5	24	170	3.6
Ore: Portland	14–17	Jan	1.31	0.8	2.2	5	21	40	1.2
	15–17	Feb	1.53	0.8	2.3	5	37	70	0.8
	15–17	Mar	2.27	1.1	3.4	5	23	90	1.4
Pa: Pittsburgh	14–16	Jan	2.27	1.4	3.2	5	34	160	1.1
	14–17	Feb	2.81	1.7	4.8	5	53	210	2.2
	15–17	Mar	2.53	1.5	3.3	5	38	150	1.8
R. I: Providence	13–15	Jan	2.49	1.7	3.7	5	37	200	1.2
	13–15	Feb	2.76	2.2	4.1	5	33	205	1.4
	NS	Mar	NS	NS	NS	NS	NS	NS	NS
Tex: Austin	14–17	Jan	2.08	0.8	2.3	5	17	40	NA
	15–17	Feb	1.89	0.9	1.9	5	15	55	NA
	15–16	Mar	1.83	0.9	2.2	5	11	55	NA
Va: Norfolk	15–16	Jan	2.28	1.1	2.7	5	39	105	NA
	15–16	Feb	2.24	1.1	2.5	5	34	90	NA
	15–16	Mar	2.35	1.2	3.3	5	33	95	NA
Wis: Milwaukee	15–17	Jan	2.21	1.1	3.8	5	20	145	2.0
	15–18	Feb	2.23	1.6	3.6	5	22	180	1.6
	14–15	Mar	1.94	1.4	2.9	5	21	115	1.0
Institutional averages for teenage boys, 13–18 years.		Jan	2.03	1.3	13.0	5	32	120	1.4
		Feb	2.23	1.5	3.2	5	42	140	1.3
		Mar	2.20	1.4	3.2	5	37	130	1.5

Key to symbols: NA, no analysis.
NS, no sample.

water is neither included in these samples nor reported. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample.

Analytical procedures

Because calcium compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program. Total weight is accurately determined in the laboratory. Stable calcium determinations are obtained by conventional gravimetric or spectrophotometric methods. Sample volumes usually range from 6 to 16 liters; sample weights range from 8 to 20 kilograms.

Results

Table 1 gives the analytical results for institutional diet samples collected from January

through March 1965. Stable elements are reported in g/kg of diet, and radionuclide concentrations are expressed as pCi/kg of diet. A maximum of 50 institutions participated in this sampling program during this period.

When discussing intake on a daily basis it is meaningful to delineate differences resulting from age and sex. In an effort to evaluate these differences, table 2 presents the dietary intake of teen-age boys on a daily basis. The intake values were obtained by multiplying the food consumption rate in kg/day times the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine–131 and barium–140 were interpreted as zero and "less than" 5 pCi/kg of strontium–89 as 2.5 pCi/kg.

Table 3 presents the daily dietary intake of teen-age girls. Table 4 presents the daily dietary intake of children 9 to 12 years of age.

A summary of these results, table 5, shows a variation between age groups. Teenage girls and younger children have comparable intakes while teen-age boys consistently have about a 20 percent higher intake. These values are comparable with the network average of 1.90 kg/day observed from 1961–1964 (*3*).

Where strontium–89 dietary intake remained below detectable levels, the strontium–90 dietary intake during this period remained fairly constant at approximately 27 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (*4*), indicating that quantitative surveillance and routine control are recommended.

Cesium–137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*3*). During this period, both barium–140 and iodine–131 concentrations were below detectable levels.

Table 3. Institutional diet daily intakes, teenage girls, first quarter 1965

Location of institution	Age (yrs)	Month (1965)	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Conn: Hartford	15–16	Jan	1.89	1.3	3.2	5	23	180	0.9
	15–16	Feb	1.56	1.1	2.7	5	22	140	0.8
	14–17	Mar	1.82	1.1	2.9	5	20	120	0.9
Ga: Atlanta	15–17	Jan [a]	1.67	0.8	2.7	5	27	110	NA
	15–17	Feb [a]	1.90	1.3	3.6	5	36	135	NA
	12–17	Mar	1.65	1.2	2.8	5	31	115	NA
La: New Orleans	15–17	Jan	2.62	1.6	3.7	5	45	260	NA
	15–17	Feb	2.55	1.8	3.8	5	33	140	NA
	14–17	Mar	2.58	1.8	3.9	5	49	155	NA
Mont: Helena	16	Jan	1.13	0.6	1.6	5	16	80	0.8
	15–16	Feb	1.68	0.8	2.2	5	35	120	0.7
	15–17	Mar	1.60	0.8	1.8	5	26	95	0.6
N. Y: New York City	14–16	Jan	2.18	1.3	3.7	5	31	195	1.7
	10	Feb [b]	2.33	1.9	3.7	5	37	165	2.3
	11–14	Mar	2.34	1.6	3.5	5	28	150	2.3
N. C: Charlotte	16–18	Jan	1.65	1.0	2.0	5	23	80	NA
	15–18	Feb	1.47	0.9	1.8	5	28	60	NA
	15–17	Mar	1.43	0.9	1.4	5	20	50	NA
Tenn: Memphis	15–16	Jan	1.27	0.8	1.5	5	20	50	NA
	15–18	Feb	1.51	0.9	2.3	5	20	55	NA
	15–17	Mar	1.48	1.0	2.2	5	21	60	NA
Utah: Salt Lake City	16	Jan	1.12	0.8	1.9	5	10	85	0.6
	15–17	Feb	1.36	0.8	1.9	5	19	80	0.5
	15–16	Mar	1.35	0.7	2.3	5	22	90	0.8
Wash: Seattle	15–16	Jan	1.43	1.1	2.0	5	51	150	0.7
	15–17	Feb	1.98	1.4	2.2	5	36	140	2.6
	14–17	Mar	1.95	1.2	2.7	5	39	155	1.2
Institutional averages for teenage girls 13–18 years.		Jan	1.66	1.1	2.4	5	27	135	0.9
		Feb	1.73	1.1	2.4	5	28	105	1.2
		Mar	1.80	1.1	2.6	5	28	110	1.2

[a] Data for this month were not used in average because food samples were collected from boys as well as girls.
[b] Data for this month were not used in average because food samples were collected from two or more children who were less than 13 years of age.
NA, no analysis.

Table 4. Institutional diet daily intakes, children (9–12 years), first quarter 1965

Location of institution	Age (yrs)	Month (1965)	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	10–12	Jan	1.43	0.9	2.1	5	19	145	0.9
	10–12	Feb	1.44	0.6	1.6	5	12	115	0.7
	10–12	Mar	1.33	0.7	1.9	5	23	80	NA
Ariz: Phoenix	12–14	Jan [a]	1.26	0.9	2.1	5	23	95	1.1
	11	Feb	1.27	1.0	2.4	5	36	125	0.9
	12–13	Mar [a]	1.21	0.8	1.8	5	24	95	0.8
Ark: Little Rock	11–12	Jan	1.81	1.3	2.2	5	36	90	NA
	10–12	Feb	1.97	1.4	2.4	5	39	90	NA
	10–12	Mar	2.02	1.2	3.0	5	44	80	NA
Calif: Los Angeles	10–15	Jan	1.03	0.5	1.6	5	8	35	1.3
	11–13	Feb	1.24	1.0	2.4	5	21	70	NA
	11–13	Mar	1.79	1.4	2.7	5	23	35	1.3
Colo: Denver	10–12	Jan	1.94	1.4	2.7	5	35	70	1.2
	11–12	Feb	1.59	0.8	2.5	5	32	70	1.0
	10–12	Mar	2.56	1.8	3.6	5	49	100	2.0
Del: Wilmington	11–12	Jan	1.86	1.5	3.3	5	22	110	1.1
	11–13	Feb	1.97	1.6	3.5	5	24	160	2.0
	11–12	Mar	1.93	1.5	3.3	5	27	155	1.0
Fla: Tampa	11–13	Jan	2.06	1.4	2.9	5	35	225	NA
	11–13	Feb	2.36	1.4	4.2	5	19	250	NA
	10–17	Mar [a]	2.49	2.0	3.5	5	30	165	NA
Ill: Chicago	10–12	Jan	1.62	1.3	2.6	5	19	140	1.0
	10–12	Feb	1.19	1.0	1.8	5	18	95	1.0
	10–12	Mar	1.68	1.3	2.7	5	24	145	0.8
Ind: Indianapolis	10–12	Jan	1.77	1.2	2.7	5	19	105	0.7
	10–11	Feb	1.70	1.5	2.6	5	24	120	0.8
	10–12	Mar	1.57	1.1	2.5	5	17	110	0.9
Kans: Wichita	10	Jan	2.27	1.6	3.6	45	34	100	NA
	10–12	Feb	1.94	1.6	3.5	5	31	95	NA
	10–12	Mar	1.96	1.6	3.3	5	31	100	NA
Md: Baltimore	11–12	Jan	2.08	1.2	2.5	5	31	85	NA
	11–12	Feb	1.85	1.1	1.8	5	26	90	NA
	11–12	Mar	1.63	1.0	2.3	5	23	80	NA
Mass: Boston A [b]	10–12	Jan	1.76	1.4	3.2	5	33	200	0.9
	10–12	Feb	2.47	1.5	3.5	5	30	200	1.0
	10–12	Mar	1.78	1.4	2.8	5	32	185	1.2
Mass: Boston B [b]	10–12	Jan	2.49	1.5	4.0	5	27	150	1.7
	9–12	Feb	2.56	1.5	3.6	5	26	100	1.5
	10–12	Mar	2.54	1.5	3.3	5	25	125	1.0
Mich: Detroit	11–12	Jan	1.74	1.4	3.0	5	23	120	1.0
	10–12	Feb	1.76	1.4	2.6	5	23	115	1.1
	10–12	Mar	2.04	1.6	3.3	5	24	175	1.6
Nev: Carson City	10–12	Jan	1.32	1.1	1.8	5	15	55	1.5
	10–12	Feb	1.37	1.8	2.5	5	63	55	2.2
	10–12	Mar	1.33	0.8	2.3	5	33	55	0.8
N. Mex: Albuquerque	10–12	Jan	1.69	1.4	2.7	5	15	40	1.2
	10–12	Feb	2.03	1.4	3.0	5	26	70	1.4
	10–12	Mar	2.24	1.8	4.0	5	22	65	2.0
N. Dak: Fargo	9–12	Jan	1.25	0.9	2.1	5	19	120	0.6
	10–12	Feb	1.39	1.1	2.4	5	15	95	0.7
	10–11	Mar	1.33	1.1	2.4	5	17	85	1.6
Ohio: Cleveland	10–11	Jan	1.81	1.4	3.1	5	22	155	0.7
	10–11	Feb	1.61	1.1	2.7	5	16	115	1.3
	10–12	Mar	1.62	1.1	2.6	5	21	115	1.3
Okla: Oklahoma City	11–12	Jan	1.68	1.3	2.9	5	27	75	NA
	10–12	Feb	1.54	0.9	2.5	5	17	55	NA
	11–14	Mar	1.66	1.2	2.8	5	23	65	NA
S. C: Charleston	11	Jan	2.56	2.3	3.8	25	64	190	NA
	11	Feb	2.07	1.2	2.9	5	29	125	NA
	11	Mar	1.13	0.8	1.7	5	18	80	NA
S. Dak: Sioux Falls	10–12	Jan	1.65	1.5	2.8	5	31	155	1.2
	10–11	Feb	1.77	1.4	2.7	5	39	135	1.2
	9–11	Mar	1.90	1.3	3.2	5	25	160	1.3
Vt: Burlington	10–12	Jan	1.53	0.9	2.6	5	21	120	0.8
	11–12	Feb	1.46	0.9	2.5	5	22	130	0.7
	10–11	Mar	1.38	0.8	2.3	5	19	125	0.6
W. Va: Charleston	10–12	Jan	1.73	1.2	2.8	15	38	110	NA
	10–12	Feb	1.90	1.3	3.4	5	32	135	NA
	10–11	Mar	1.78	1.4	3.4	5	28	90	NA
Wyo: Laramie	11	Jan	1.44	1.0	2.9	5	17	95	2.7
	11	Feb	1.20	1.0	1.7	5	19	55	1.1
	11	Mar	1.77	1.2	2.7	5	25	95	1.2
Institutional averages for children, 9–12 years.		Jan	1.76	1.3	2.8	5	27	115	1.2
		Feb	1.74	1.2	2.7	5	27	110	1.2
		Mar	1.77	1.3	2.8	5	26	105	1.2

[a] Data for this month were not used to obtain average for younger school children since school had included food samples for two or more children aged 13 years or more.

[b] "A" and "B" denote two separate institutions in Boston.

NA, no analysis.

Table 5. Summary of ITDSN intakes for January through March, 1965

Sampling groups	Month	No. of institutions	Weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day					
				Calcium	Potassium	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140	Radium-226
Teenage boys	Jan	16	2.03	1.3	3.0	5	32	0	120	0	1.4
	Feb	17	2.23	1.5	3.2	5	42	0	140	0	1.3
	Mar	16	2.20	1.5	3.2	5	37	0	130	0	1.5
Teenage girls	Jan	8	1.66	1.1	2.4	5	27	0	[a]135	0	0.9
	Feb	7	1.73	1.1	2.4	5	28	0	105	0	1.2
	Mar	9	1.80	1.1	2.6	5	28	0	110	0	1.2
Children	Jan	24	1.76	1.3	2.8	5	27	0	115	0	1.2
	Feb	24	1.74	1.2	2.7	5	27	0	110	0	1.2
	Mar	24	1.77	1.3	2.8	5	26	0	105	0	1.2

[a] Includes New Orleans, La., and Seattle, Wash., which had high cesium-137 concentrations relative to other stations.

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Recent coverage in *Radiological Health Data:*

Period	Issue
July–September 1963	*March 1964*
October–December 1963	*July 1964*
January–March 1964	*October 1964*
April–June 1964	*January 1965*
July–September 1964	*April 1965*
October–December 1964	*July 1965*

Section III—Water

GROSS RADIOACTIVITY, APRIL 1965, AND STRONTIUM-90, OCTOBER 1964–MARCH 1965, IN SURFACE WATERS OF THE UNITED STATES

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–8*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term increases in radioactivity from current or recent nuclear tests or events.

Normally, samples are counted within 2 weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on the recount are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (9). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents the most recent results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative locations, the first station listed being closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean

is between zero and 0.5, the mean is reported as <1 pCi/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity.

Strontium–90 determinations and results

Beginning in 1959, strontium–90 analyses of the total solids in surface waters were made quarterly on 3-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except at those stations immediately below nuclear installations, where regular quarterly analyses were continued. The method used for determining strontium–90 is a modification of a procedure described by Harley (*10*). The yttrium–90 together with yttrium carrier is precipitated as yttrium oxalate and the latter is washed, dried, weighted, and

Table 1. Radioactivity in raw surface waters, April 1965

(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	35	10	45	7	2	9
Arkansas River:						
Coolidge, Kans.	15	28	43	5	29	34
Ponca City, Okla.	74	23	97	14	1	15
Atchafalaya River:						
Morgan City, La.	27	9	36	8	1	9
Bear River:						
Preston, Idaho	1	15	16	0	3	3
Big Horn River:						
Hardin, Mont.	74	23	97	6	3	9
Chattahoochee River:						
Atlanta, Ga.	8	4	12	3	0	3
Chena River:						
Fairbanks, Alaska	2	7	9	0	1	1
Clearwater River:						
Lewiston, Idaho	12	4	16	2	0	2
Clinch River:						
Clinton, Tenn.	0	4	4	0	0	0
Kingston, Tenn.	1	22	23	0	1	1
Colorado River:						
Loma, Colo.	60	18	78	6	3	9
Page, Ariz.	1	28	29	0	7	7
Boulder City, Nev.	0	24	24	0	10	10
Parker Dam, Calif-Ariz.	1	17	18	0	7	7
Columbia River:						
Wenatchee, Wash.	0	6	6	0	1	1
Pasco, Wash.	104	439	543	0	1	1
Bonneville, Oreg.	38	83	121	0	1	1
Clatskanie, Ore.	30	105	135	1	0	1
Connecticut River:						
Enfield Dam, Conn.	3	5	8	0	0	0
Coosa River:						
Rome, Ga.	4	4	8	1	0	1
Cumberland River:						
Cheatham Lock, Tenn.	4	5	9	1	0	1
Delaware River:						
Philadelphia, Pa.	3	6	9	1	0	1
Great Lakes:						
Duluth, Minn.	1	3	4	0	0	0
Buffalo, N. Y.	1	11	12	0	1	1
Green River:						
Dutch John, Utah	1	21	22	0	5	5
Hudson River:						
Poughkeepsie, N.Y.	3	8	11	0	0	0
Kansas River:						
De Soto, Kans.	35	16	51	6	2	8
Klamath River:						
Keno, Oreg.	2	14	16	0	1	1
Maumee River:						
Toledo, Ohio	15	15	30	2	0	2
Mississippi River:						
St. Paul, Minn.	3	19	22	0	0	0
E. St. Louis, Ill.	34	15	49	6	0	6
Cape Girardeau, Mo.	13	19	32	1	2	3
New Roads, La.	20	10	30	5	1	6
New Orleans, La.	65	11	76	40	1	41
Missouri River:						
Williston, N. Dak.	10	18	28	2	3	5
Bismarck, N. Dak.	17	18	35	4	4	8
St. Joseph, Mo.	94	21	115	24	4	28
North Platte River:						
Henry, Nebr.	2	35	37	0	32	32
Ohio River:						
Toronto, Ohio	2	5	7	<1	0	<1
Addison, Ohio	9	6	15	2	0	2
Cairo, Ill.	13	9	22	4	0	4
Ouachita River:						
Bastrop, La.	2	13	15	0	1	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	5	6	<1	<1	<1
Platte River:						
Plattsmouth, Nebr.	153	22	175	42	5	47
Potomac River:						
Washington, D.C.	0	3	3	0	0	0
Rainy River:						
Baudette, Minn.	5	18	23	<1	<1	<1
Red River, North:						
Grand Forks, N. Dak.	11	32	43	1	2	3
Red River, South:						
Alexandria, La.	16	13	29	4	0	4
Rio Grande:						
Alamosa, Colo.	1	7	8	1	1	2
El Paso, Tex.	42	25	67	5	1	6
Laredo, Tex.	2	9	11	0	4	4
Brownsville, Tex.	4	11	15	1	4	5
San Joaquin River:						
Vernalis, Calif.	3	7	10	1	1	2
San Juan River:						
Shiprock, N. Mex.	71	13	84	22	4	26
Savannah River:						
Port Wentworth, Ga.	2	8	10	0	0	0
Shenandoah River:						
Berryville, Va.	2	4	6	0	0	0
Ship Creek:						
Anchorage, Alaska	1	1	2	0	0	0
Snake River:						
Payette, Idaho	4	8	12	1	2	3
Wawawai, Wash.	8	6	14	1	1	2
South Platte River:						
Julesburg, Colo.	6	54	60	1	42	43
Susquehanna River:						
Conowingo, Md.	1	4	5	0	0	0
Tennessee River:						
Chattanooga, Tenn.	3	8	11	0	0	0
Bridgeport, Ala.	1	7	8	0	1	1
Wabash River:						
New Harmony, Ind.	10	14	24	2	1	3
Yellowstone River:						
Sidney, Mont.	88	22	110	25	5	30
Maximum	153	439	543	42	42	47
Minimum	0	1	2	0	0	0

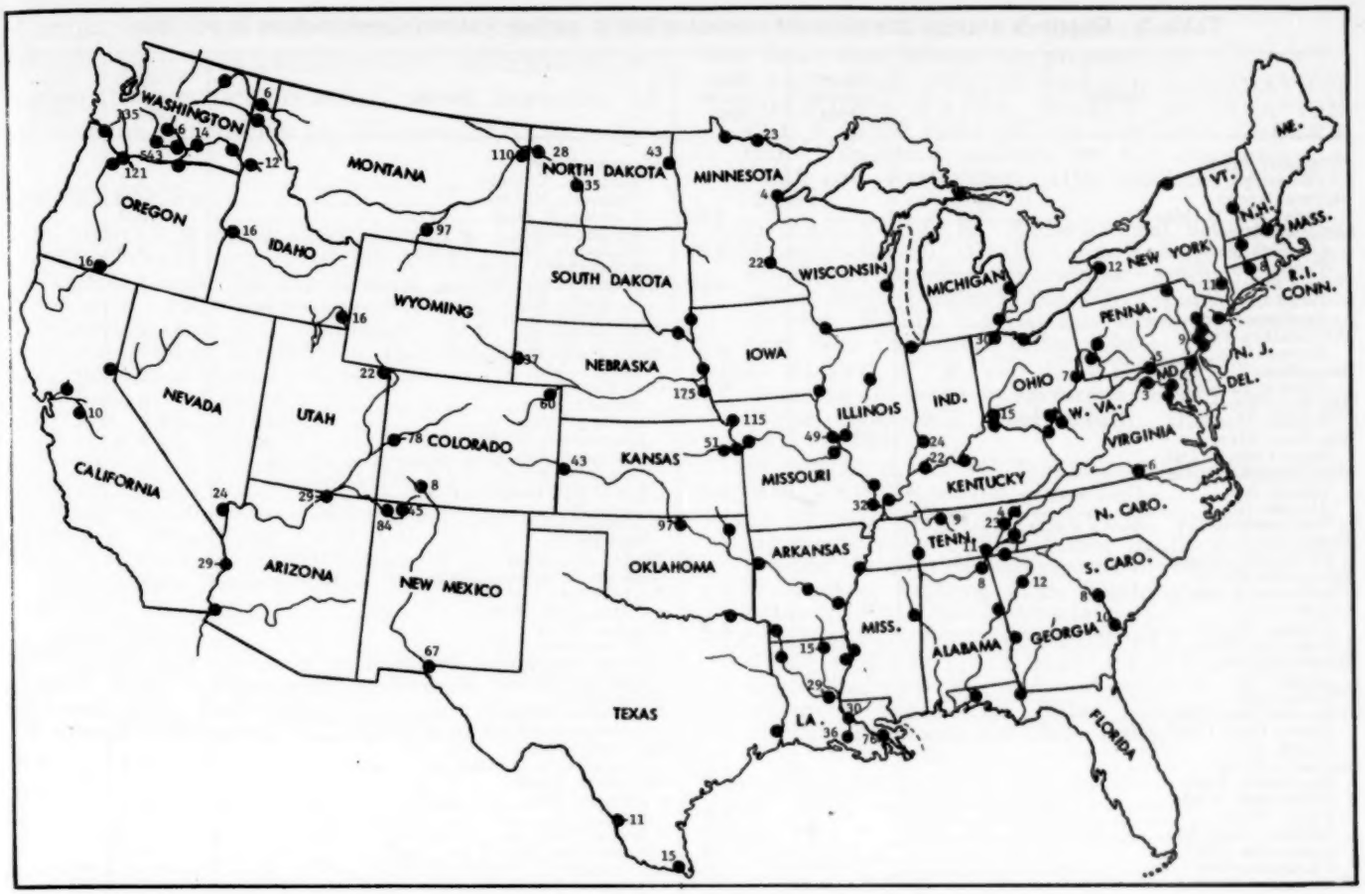

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, April 1965

counted in a low-background, anticoincidence, end-window proportional counter.

Table 2 presents the results of quarterly analyses of strontium–90 concentrations in U.S. surface waters for the fourth quarter of 1964 and the first quarter of 1965. Floyd and Weaver summarized the strontium–90 results obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*11*). The stations are arranged in the table according to their relative locations on the river, the first station being closest to the headwaters.

Discussion of results

The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*12*). The Public Health Service Drinking Water Standards state that in the absence of alpha emitters and strontium–90, a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*13*).[1] In table 1, the following stations show relatively high values for alpha and beta radioactivity because of parallel high suspended solids: Missouri River—St. Joseph, Missouri; Platte River—Plattsmouth, Nebraska; and Yellowstone River—Sidney, Montana. Other stations showing high levels of alpha and beta activity were: Mississippi River—New Orleans, Louisiana, and San Juan River—Shiprock, New Mexico.

While there are no standards for strontium–90 activity of total solids in surface waters, the Public Health Service Drinking Water Standards set the limit for strontium–90 concentrations in drinking water at 10 pCi/liter (*13*). During the fourth quarter of 1964, and the first quarter of 1965, this limit was not exceeded. Comparison between the two quarters is not feasible at all sampling locations due to fluctuations in sampling frequencies.

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for alpha emitters and strontium–90, respectively.

Table 2. Quarterly average strontium-90 concentrations in surface waters (concentrations in pCi/liter)

Station	Fourth quarter 1964	First quarter 1965
Allegheny River:		
Pittsburgh, Pa	1.7	
Animas River:		
Cedar Hill, N. Mex		1.3
Arkansas River:		
Coolidge, Kans		0.4
Ponca City, Okla	2.9	
Fort Smith, Ark		3.6
Little Rock, Ark	2.9	
Pendleton Ferry, Ark	2.8	
Atchafalaya River:		
Morgan City, La		4.6
Bear River:		
Preston, Idaho		0.7
Big Horn River:		
Hardin, Mont	1.7	
Big Sioux River:		
Sioux Falls, S. Dak		1.9
Chattahoochee River:		
Lanett, Ala		0.9
Atlanta, Ga	1.6	
Columbus, Ga	1.2	
Chena River:		
Fairbanks, Alaska	0.1	
Clearwater River:		
Lewiston, Idaho		0.4
Clinch River:		
Clinton, Tenn		1.2
Kingston, Tenn	3.0	2.6
Colorado River:		
Loma, Colo	0.9	
Page, Ariz		3.9
Boulder City, Nev	1.7	
Parker Dam, Calif.-Ariz		1.0
Yuma, Ariz	1.2	
Columbia River:		
Northport, Wash		0.9
Wenatchee, Wash	1.8	
Pasco, Wash	2.2	1.9
McNary Dam, Ore	1.6	1.0
Bonneville, Ore		1.3
Clatskanie, Ore	1.0	
Connecticut River:		
Wilder, Vt		0.8
Northfield, Mass	1.3	
Enfield Dam, Conn		1.0
Coosa River:		
Rome, Ga		0.8
Cumberland River:		
Cheatham Lock, Tenn		1.0
Cuyahoga River:		
Cleveland, Ohio		2.5
Delaware River:		
Martins Creek, Pa	1.3	
Trenton, N. J		1.1
Philadelphia, Pa	1.2	
Escambia River:		
Century, Fla	0.9	
Great Lakes:		
Duluth, Minn	0.5	
Sault Ste. Marie, Mich		0.6
Milwaukee, Wis	0.8	
Gary, Ind		0.9
Port Huron, Mich	1.2	
Detroit, Mich		1.3
Buffalo, N. Y	2.3	
Green River:		
Dutch John, Utah		1.0
Hudson River:		
Poughkeepsie, N. Y	2.0	
Illinois River:		
Peoria, Ill	1.6	
Kanawha River:		
Winfield Dam, W. Va		0.7
Kansas River:		
De Soto, Kans	3.3	
Klamath River:		
Keno, Ore	1.5	
Little Miami River:		
Cincinnati, Ohio		2.2
Maumee River:		
Toledo, Ohio	2.1	
Merrimack River:		
Lowell, Mass		0.6
Mississippi River:		
St. Paul, Minn		3.1
Dubuque, Iowa	2.9	
Burlington, Iowa		2.6
E. St. Louis, Ill	2.7	
Cape Girardeau, Mo		3.2
W. Memphis, Ark	2.2	
Vicksburg, Miss		1.9
Delta, La	2.4	
New Roads, La	2.1	
New Orleans, La		1.7
Missouri River:		
Williston, N. Dak	2.1	
Bismarck, N. Dak		3.4
Yankton, S. Dak	3.3	
Omaha, Nebr		2.6
St. Joseph, Mo	3.0	
Kansas City, Kans		2.8
Missouri City, Mo	3.6	
St. Louis, Mo		2.4
Monongahela River:		
Pittsburgh, Pa	1.8	
North Platte River:		
Henry, Nebr	0.5	
Ohio River:		
Toronto, Ohio	2.0	
Addison, Ohio		0.9
Huntington, W. Va	1.4	
Cincinnati, Ohio		1.3
Louisville, Ky	2.1	
Evansville, Ind		1.5
Cairo, Ill	2.1	
Ouachita River:		
Bastrop, La		2.0
Pend Oreille River:		
Albeni Falls Dam, Idaho	1.0	
Platte River:		
Plattsmouth, Nebr		2.0
Potomac River:		
Williamsport, Md	0.8	
Great Falls, Md		0.9
Washington, D. C		1.1
Rainy River:		
Baudette, Minn	3.5	
International Falls, Minn	3.2	
Red River, North:		
Grand Forks, N. Dak	5.4	5.3
Red River, South:		
Denison, Tex		4.9
Index, Ark	3.4	
Bossier City, La		1.7
Alexandria, La	2.7	
Rio Grande:		
Alamosa, Colo	0.7	
El Paso, Tex		0.4
Laredo, Tex	1.7	
Brownsville, Tex		2.
Roanoke River:		
John H. Kerr Resr/Dam, Va	1.5	
Sabine River:		
Ruliff, Tex		1.6
Sacramento River:		
Greens Landing, Calif		0.8
St. Lawrence River:		
Massena, N. Y		1
San Joaquin River:		
Vernalis, Calif	1.0	
San Juan River:		
Shiprock, N. Mex	2.1	
Savannah River:		
North Augusta, S. C		1.2
Port Wentworth, Ga	1.8	1.4
Schuylkill River:		
Philadelphia, Pa		1.5
Shenandoah River:		
Berryville, Va	0.5	
Ship Creek:		
Anchorage, Alaska		0.2
Snake River:		
Payette, Idaho	0.6	
Wawawai, Wash	0.6	
Ice Harbor Dam, Wash		0.5
South Platte River:		
Julesburg, Colo	0.7	
Spokane River:		
Post Falls Dam, Idaho		0.7
Susquehanna River:		
Savre, Pa		0.7
Tennessee River:		
Lenoir City, Tenn	1.2	
Chattanooga, Tenn	1.3	1.2
Bridgeport, Ala	1.0	
Pickwick Landing, Tenn		1.2
Tombigbee River:		
Columbus, Miss		1.5
Truckee River:		
Farad, Calif	0.6	
Verdigris River:		
Nowata, Okla	3.0	
Wabash River:		
New Harmony, Ind	1.6	
Willamette River:		
Portland, Oreg	0.3	
Yakima River:		
Richland, Wash		0.4
Yellowstone River:		
Sidney, Mont		1.7

Comparison with results prior to October 1964 should take into consideration instrument recalibration which resulted in a lowering of strontium–90 values by 15 percent (*14*).

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[2] Single free copies of this publication may be obtained from Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

DRINKING WATER ANALYSIS PROGRAM, 1962[1]

Division of Environmental Engineering and Food Protection, and Division of Radiological Health, Public Health Service

The Drinking Water Analysis Program, initiated in November 1960, provides data on radioactivity levels in the water supplies of 139 municipalities. This program is conducted under the Public Health Service's Interstate Carrier Branch which is responsible for the certification of drinking water supplies used by Interstate Common Carriers.

Figure 1 shows the nationwide distribution of the 139 municipalities included in the second sampling, conducted during 1962. Where more than one source of drinking water exists in a municipality, each source is sampled.

The drinking water standards for radionuclides (*1*) are conservative in their requirements so that the total intake of these nuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (*2*).

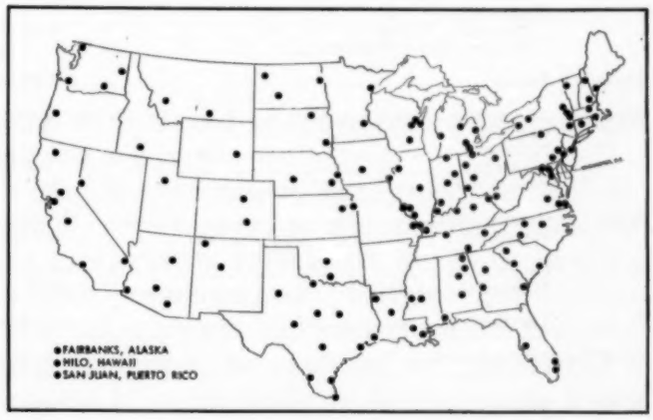

Figure 1. Drinking water analysis program sampling stations.

[1] Summarized from "Drinking Water Quality of Selected Interstate Carrier Water Supplies, 1962–1963," U.S. Public Health Service, PHS Publication No. 1049–A.

Table 1. Radioactivity concentration (pCi/liter) in drinking waters, December 1961–June 1963

Sampling location		Sampling periods [a]	Strontium-90 in total solids	Alpha activity		Beta activity	
State	City			Dissolved	Suspended	Dissolved	Suspended
Ala:	Birmingham						
	Shades Pl	5/4–5/19	—	—	—	8.8	<3.0
	Putnam Pl	5/2–5/18	—	—	—	5.2	<3.0
	Gadsden	3/14–3/28	—	—	—	14.0	<3.0
	Mobile	5/1–5/15	—	—	—	14.0	<3.0
Conn:	Hartford	12/5–12/18	<1.0	<1.0	<1.0	4.0	1.0
Del:	Wilmington						
	Porter FP	9/11–9/24	<1.0	<1.0	<1.0	3.0	<1.0
	Brandywine FP	10/2–10/15	<1.0	<1.0	<1.0	5.0	<1.0
Fla:	Ft. Lauderdale						
	Dixie Pl	9/19–10/9	—	—	—	3.0	3.0
	Fiveash Pl	9/19–10/3	—	—	—	<3.0	<3.0
	Miami						
	Hialeah Pl	11/8–11/22	—	—	—	<3.0	<3.0
	Orr Pl	11/8–11/22	—	—	—	<3.0	<3.0
	Tampa	9/18–10/3	—	—	—	10.0	<3.0
Ga:	Atlanta						
	Chattahoochee Pl	3/13–3/29	—	—	—	7.9	<3.0
	Memphill Pl	12/17–1/2/63	—	—	—	8.8	<3.0
	Columbus	1/10/63–1/28/63	—	—	—	11.8	<3.0
	Savannah						
	Ind.–Domestic Supply	8/2–8/16	—	—	—	5.9	3.0
	Well Supply	8/2–8/16	—	—	—	<3.0	<3.0
Ill:	Cairo	6/29–7/13	<1.0	<1.0	<1.0	<1.0	<1.0
Ind:	Elkhart	2/19–3/5	—	—	—	<3.0	<3.0
	Evansville	8/6–8/21	<1.0	<1.0	<1.0	4.0	<1.0
	Indianapolis						
	White River Pl	5/16–5/30	—	—	—	12.1	<3.0
	Fall Creek Pl	5/14–5/29	—	—	—	15.0	<3.0
	Muncie	5/24–6/7	—	—	—	19.0	<3.0
	Washington	8/6–8/20	<1.0	0.0	0.1	0.1	0.0
Iowa:	Burlington	1/4–1/18	—	1.0	—	9.3	0.3
Ky:	Paducah	3/7–3/21	—	—	—	22.0	<3.0
La:	Alexandria	10/24–11/14	—	—	—	5.1	<3.0
	Baton Rouge	9/20–10/30	—	—	—	9.4	3.0
	New Orleans	11/6–11/20	—	—	—	7.2	<3.0
	Shreveport						
	Cross Lake Pl	9/20–10/16	—	—	—	<3.0	<3.0
	McNeill St. Pl	9/21–10/8	—	—	—	8.8	<3.0
Maine:	Portland	10/10–10/26	<1.0	<1.0	<1.0	7.0	<1.0
Md:	Baltimore						
	Montebello Pl	6/13/63–6/26/63	—	—	—	8.7	<3.0
	Hagerstown						
	Mountain Supply	5/14–5/29	—	—	—	5.8	<3.0
	Potomac River Station	5/15–5/28	—	—	—	10.0	<3.0
Mass:	Lowell	2/5/63–2/18/63	<1.0	<1.0	<1.0	3.0	<1.0
Mich:	Ann Arbor	9/10–10/3	<1.0	<1.0	<1.0	3.0	<1.0
	Bay City	4/4–4/20	2.4	—	—	16.0	<3.0
	Monroe	9/17–10/2	<1.0	<1.0	<1.0	3.0	<1.0
	Muskegon	4/6–4/23	<1.0	—	—	7.3	<3.0
	Port Huron	9/17–9/30	<1.0	<1.0	<1.0	4.0	2.0
Miss:	Greenville	10/25–11/9	—	—	—	<3.0	<3.0
	Vicksburg	8/13–8/28	—	—	—	11.4	<3.0
N. H:	Berlin	10/15–10/30	<1.0	<1.0	<1.0	6.0	<1.0
	Manchester	10/20–11/2	<1.0	<1.0	<1.0	8.0	1.0
N. J:	Trenton	10/10–10/25	<1.0	<1.0	<1.0	4.0	<1.0
N. Mex:	Albuquerque	8/2–8/17	—	—	—	<3.0	3.3
	Farmington	8/6–8/21	—	—	—	4.8	<3.0
N. Y:	Albany	3/27–4/9	2.0	—	—	14.0	<3.0
	Buffalo	9/4–9/18	<1.0	0.0	0.1	3.8	0.4
	New York City						
	Woodhaven W.S.	2/2–2/19	—	—	—	<3.0	<3.0
	Poughkeepsie	12/3–12/20	<1.0	<1.0	<1.0	8.0	<1.0
	Rochester						
	Lake Hemlock	8/29–9/12	<1.0	<1.0	<1.0	6.0	4.0
	Lake Ontario	8/30–9/13	<1.0	0.1	0.1	2.2	4.8
	Monroe Co. W. Authority	8/30–9/15	<1.0	<1.0	<1.0	1.0	<1.0
	Schenectady	3/22–4/5	—	—	—	<3.0	<3.0
	Troy	4/11–4/28	<1.0	—	—	18.0	4.0
N. C:	Raleigh	3/22–4/5	1.6	—	—	19.0	<3.0
Ohio:	Akron	2/19–3/4	—	—	—	15.0	<3.0
	Cincinnati	8/6–8/20	<1.0	<1.0	<1.0	5.0	<1.0
	Lima	8/6–8/20	<1.0	<1.0	<1.0	5.4	<1.0
	Springfield	8/6–8/20	<1.0	0.0	0.1	0.8	0.6
	Toledo	2/19–3/7	—	—	—	8.1	3.0

Table 1. Radioactivity concentration (pCi/liter) in drinking waters, December 1961–June 1963—Continued

Sampling location		Sampling periods [a]	Strontium-90 in total solids	Alpha activity		Beta activity	
State	City			Dissolved	Suspended	Dissolved	Suspended
Okla:	Oklahoma City						
	Lake Hefner	4/26–5/14	—	—	—	12.0	<3.0
	Lake Overholser	5/3–5/17	—	—	—	12.0	<3.0
Pa:	Allentown	11/28–12/12	<1.0	<1.0	<1.0	1.0	<1.0
	Lancaster						
	Conestoga Pl	1/7/63–1/22/63	<1.0	<1.0	<1.0	9.0	<1.0
	Philadelphia						
	Belmont Filters (SS–RS)	12/21/61–1/6	—	—	—	11.0	<3.0
	Queen Lane Pl	12/21/61–1/4	—	—	—	14.0	<3.0
	Belmont Filters (RS)	12/21/61–1/6	—	—	—	13.0	<3.0
	Torresdale Pl	12/21/61–1/4	—	—	—	11.0	<3.0
	Sayre	9/4–9/22	<1.0	<1.0	<1.0	3.0	<1.0
S. C:	Charleston	2/11/63–2/26/63				14.8	<1.0
	Greenville	2/17/63–2/22/63				9.6	3.2
S. Dak:	Sioux Falls	2/21–3/9	—	—	—	8.0	1.0
Tenn:	Chattanooga	1/25–2/2	—	—	—	14.0	<3.0
	Clarkesville	2/3–2/18	—	—	—	8.4	<3.0
	Knoxville	2/6–2/20	—	—	—	7.8	<3.0
Tex:	Brownsville						
	Plant No. 1	3/9–3/23	—	—	—	5.3	<3.0
	Plant No. 2	3/9–3/23	—	—	—	8.6	<3.0
	Brownwood	1/15–1/31	—	—	—	11.1	<3.0
	Laredo	3/1–3/16	—	—	—	19.0	<3.0
	Port Arthur	6/14–6/18	—	—	—	35.0	<3.0
	San Angelo	5/25–6/9	—	—	—	16.0	<3.0
	San Antonio	12/13/61–12/24/61	—	—	—	16.0	<3.0
	Waco	5/30–6/14	—	—	—	21.0	<3.0
	Wichita Falls	5/29–6/13	—	—	—	15.0	<3.0
Vt:	Burlington	12/11–12/29	<1.0	<1.0	<1.0	5.0	1.0
Va:	Norfolk						
	Moores Bridge Pl	4/9–4/25	—	—	—	21.0	<3.0
	37th Street Pl	4/9–4/24	1.3	—	—	20.0	<3.0
	Portsmouth	3/1–3/17	—	—	—	5.1	<3.0
	Richmond	3/18/63–5/3/63	—	—	—	8.1	<1.0
W. Va:	Huntington	6/7–6/22	—	—	—	6.8	<3.0
Wis:	Green Bay	9/17–10/2	<1.0	<1.0	<1.0	3.0	<1.0
	Manitowoc	11/5–11/23	<1.0	<1.0	<1.0	2.0	<1.0
	Neenah	10/19–11/1	—	<1.0	<1.0	5.0	<1.0

[a] 1962 unless otherwise indicated.

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium–226 or 10 pCi/liter of strontium–90. In the absence of strontium–90 (much less than 10 pCi/liter), and in the absence of alpha emitters (much less than 3 pCi/liter), the water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources is within the guidance recommended by the Federal Radiation Council for control action. When mixtures of radionuclides are present, the proportion of each radionuclide to its maximum limit should be considered when evaluating the exposure.

The determinations performed on the selected carrier supplies are sanitary chemical analyses, carbon chloroform analyses, spectrographic examinations, certain quantitative chemical analyses, and radiochemical analyses. Each sample to be analyzed for radionuclides consists of a composite of three aliquots a day obtained over a 2-week period. The analyses for gross alpha activity and strontium–90 are performed at the Southeastern, Northeastern, and Southwestern Radiological Health Laboratories, operated by the Division of Radiological Health.

The sensitivity of the analytical method requires that results on some samples be reported as "less than" a stated value. In statistically

Table 2. Frequency distribution of radioactivity concentrations (pCi/liter) levels in drinking waters, 1962 (December 1961–June 1963).

Strontium-90 activity		Dissolved beta activity	
Range from 1.0—2.4 Arithmetic mean—1.1 Total number of supplies—34 Number of "less than" values—30		Range from 0.1—35.0 Arithmetic mean—8.9 Total number of supplies—96 Number of "less than" values—11	
Interval	Number of supplies	Interval	Number of supplies
<1.0	30	0.0–1.9	5
1.2–1.4	1	2.0–2.9	2
1.5–1.7	1	3.0–3.9	17
1.8–2.0	1	4.0–4.9	5
2.1–2.3	0	5.0–5.9	11
2.4–2.6	1	6.0–6.9	3
2.7–2.9	0	7.0–7.9	5
>2.9	0	8.0–8.9	11
		9.0–9.9	4
		10.0–10.9	2
		11.0–11.9	5
		12.0–12.9	3
		13.0–13.9	1
		14.0–14.9	6
		15.0–15.9	3
		>15.9	13

Suspended beta activity		Dissolved alpha activity		Suspended alpha activity	
Range from 0.0—4.8 Arithmetic mean—2.4 Total number of supplies—96 Number of "less than" values—78		Range from 0.0—1.0 Arithmetic mean—0.9 Total number of supplies—30 Number of "less than" values—25		Range from 0.1—1.0 Arithmetic mean—0.9 Total number of supplies—29 Number of "less than" values—25	
Interval	Number of supplies	Interval	Number of supplies	Interval	Number of supplies
0.0–0.9	4	0.0–0.4	4	0.0–0.4	4
1.0–1.9	26	0.5–0.9	0	0.5–0.9	0
2.0–2.9	1	1.0–1.4	26	1.0–1.4	25
3.0–3.9	64	>1.4	0	>1.4	0
>3.9	1				

Table 3. Frequency distribution of radioactivity concentration (pCi/liter) levels in drinking waters, 1961 (November 1960–February 1962)

Strontium-90 activity		Dissolved beta activity	
Range from 0.1 to 3.3 Arithmetic mean—1.0 Total number of supplies—27 Number of "less than" values—8		Range from 0.6 to 300.0 Arithmetic mean—7.2 Total number of supplies—141 Number of "less than" values—56	
Interval	Number of supplies	Interval	Number of supplies
0.0–0.2	4	0.0–1.9	4
0.3–0.5	4	2.0–2.9	16
0.6–0.8	4	3.0–3.9	67
0.9–1.1	10	4.0–4.9	12
2.2–1.4	1	5.0–5.9	10
1.5–1.7	0	6.0–6.9	11
1.8–2.0	2	7.0–7.9	4
2.1–2.3	0	8.0–8.9	1
2.4–2.6	0	9.0–9.9	1
2.7–2.9	0	10.0–10.9	3
>2.9	2	11.0–11.9	2
		12.0–12.9	3
		13.0–13.9	1
		14.0–14.9	1
		15.0–15.9	1
		>15.9	4

Suspended beta activity		Dissolved alpha activity		Suspended alpha activity	
Range from 0.3 to 35.0 Arithmetic mean—3.0 Total number of supplies—120 Number of "less than" values—116		Range from 0.5—19.9 Arithmetic mean—1.5 Total number of supplies—80 Number of "less than" values—70		Range from 0.1—9.4 Arithmetic mean—0.7 Total number of supplies—66 Number of "less than" values—62	
Interval	Number of supplies	Interval	Number of supplies	Interval	Number of supplies
0.0–0.9	2	0.0–0.4	0	0.0–0.4	2
1.0–1.9	15	0.5–0.9	69	0.5–0.9	61
2.0–2.9	7	1.0–1.4	0	1.0–1.4	1
3.0–3.9	93	>1.4	11	>1.4	2
>3.9	3				

treating the data, the full "less than" value is used. The effect of this is to place an upper limit on the results, which is quite satisfactory for surveillance and control action.

Table 1 presents data from the 1962 sampling, which was conducted from December 1961 to June 1963. In table 2, the same data are arranged to facilitate rapid visual comprehension, and in table 3, the data from the 1961 sampling (conducted from November 1960 to February 1962), are similarly arranged (*3*, *4*). Each item is shown in terms of its nationwide frequency distribution, range and mean. Also presented are the total number of supplies which provide the data, and the number of "less than" (<) values.

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(*3*) PUBLIC HEALTH SERVICE. Radioactivity in drinking water, 1961. Rad Health Data 3:157–158 (May 1962): 254–255 (August 1962): 411–412 (October 1962); 4:37–39 (January 1963).

(*4*) PUBLIC HEALTH SERVICE. Drinking water quality of selected Interstate carrier water supplies, 1960–1961. PHS Publication 1049 (June 1963).

RADIOLOGICAL SURVEY OF THE LOWER COLUMBIA RIVER IN OREGON, AUGUST 1963–JULY 1964[1]

George L. Toombs[2]

The Lower Columbia River Radiological Survey in Oregon was initiated in June 1961, with routine sample collection and analyses beginning in January 1962. This Survey is jointly funded by the Oregon State Board of Health and the Division of Radiological Health, U.S. Public Health Service.[3] The major objective is to determine and monitor the distribution of radionuclides in environmental media in the lower Columbia River and along the Oregon seacoast.

Hanford Atomic Products Operation, the major source of the radionuclide contaminants observed, is located on the upper Columbia River at Richland, Washington (see figure 1) and consists of a 500-square-mile complex of nuclear reactors, fuel fabrication plants, chemical separation facilities, and research and development laboratories. The Hanford reactor cooling waters add radioactivity to the Columbia River at a rate of several thousand curies per day. Hanford conducts an extensive environmental radiation surveillance program with Vancouver, Washington, being the farthest downstream location where river water and biota are sampled monthly.

This Lower Columbia River Study extends on a monthly basis, the radiological surveillance in the Columbia River to its confluence with the Pacific Ocean at Astoria, Oregon, and along the Oregon seacoast. During the period 1961–1963 the University of Washington, Department of Radiation Biology, maintained a routine sampling program along the Oregon seacoast. Routine monthly surveillance in this area is now provided by this Lower Columbia River study.

In addition to the Hanford surveillance programs and this Lower Columbia River study, other surveillance and research programs, concerned with the ecological factors and fate of radioactivity originating from Hanford, are supported by the U.S. Atomic Energy Commission and the U.S. Public Health Service. The areas involved in these programs are the Columbia River itself and beyond its mouth as far as 500 miles into the Pacific Ocean. Agencies involved in these studies are the University of Washington, Oregon State University, Washington State Department of Health, U.S. Geological Survey, Army Corps of Engineers, and the Bureau of Commercial Fisheries.

The data obtained from this Lower Columbia River Study, the Hanford surveillance program along with data on radioactivity in Washington and U.S. Surface Waters, are published routinely in Radiological Health Data (1–4).

Sampling procedures

The following criteria were used in the selection of sampling locations: (1) availability of samples which could be used to describe the concentrations of the radionuclides present in the environment; (2) accessibility on a year-round basis, and (3) avoidance of needless duplication of the sampling efforts of similar programs.

Samples were obtained on a monthly basis from five regular Columbia River and Oregon seacoast locations. Sampling during prior periods at John Day Dam and Arlington was discontinued early in 1964 due to construction in those areas which caused significant changes in environmental conditions at the sampling locations. In addition to the monthly sampling, a comprehensive sampling survey was conducted during April 1964 along the Oregon seacoast extending southward to Yaquina Bay. The sampling stations in this survey were previously used during the period 1961–1963 for similar sampling by the University of Washington, Department of Radiation Biology.

[1] Summarized from "Lower Columbia River Environmental Radiological Survey in Oregon, 1963–1964," Division of Sanitation and Engineering, Oregon State Board of Health.

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[3] This work was performed by the Oregon State Board of Health under Contract No. SAph 76874 between the U.S. Public Health Service and the Oregon State Board of Health.

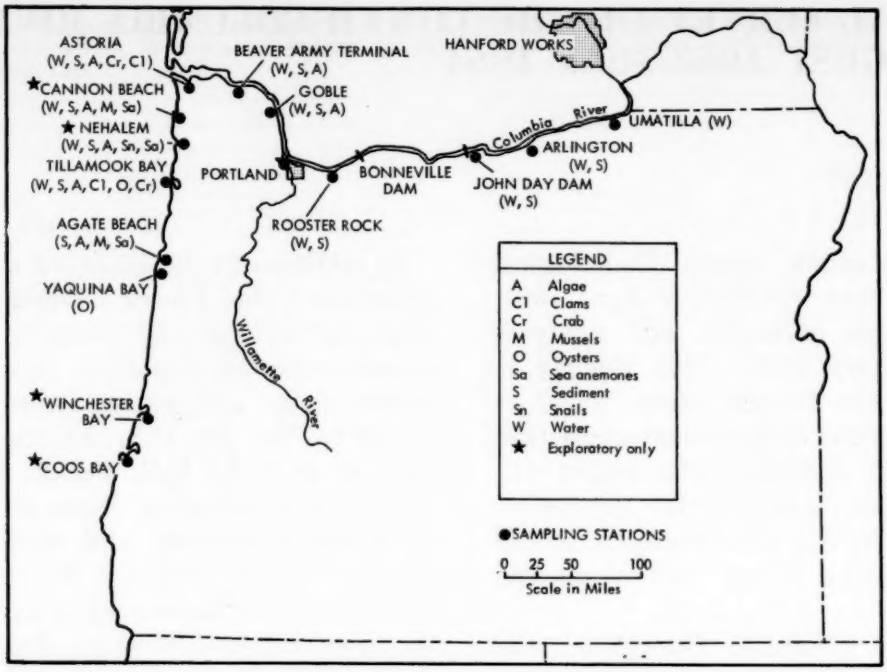

Figure 1. Columbia River study sampling locations

Water samples were collected in two-liter polyethylene bottles, as far out from the shore as was practical. Two milliliters of concentrated hydrochloric acid were added to each sample to prevent plating of the radionuclides onto the container surfaces and to keep dissolved substances in solution. Sediment samples were collected by scooping up approximately one liter of the top inch of deposits. Sediment and algae samples were collected from the shallow water along the shoreline, except at Tillamook Bay, where samples were collected on a mud flat which was accessible at low tide. Crab and oyster samples were obtained by purchase from local producers while all other shellfish were hand-gathered.

Analytical procedures

Samples were routinely analyzed utilizing gamma spectrometry, within one week after collection. Water, sediment, and algae samples were gamma-scanned in their original state. Shellfish samples were counted with the shell removed and included all soft parts and body liquids, but excluded mantle liquid. The edible portions of the crab, clam, and oyster samples were counted with normal tissue liquid. The usual counting periods were 100 minutes; however, some low-activity samples were counted as long as 800 minutes to achieve good counting statistics. All radionuclide concentrations were extrapolated to the date of collection.

Calibration and counting efficiencies for the gamma spectrometer system were determined by the use of standard liquid radionuclide sources. To eliminate the contribution to a given photopeak from higher-energy interfering radionuclides, Compton scatter corrections were calculated using the data from the standard radionuclide spectra. By approximating the portion of the count rate in the photopeak caused by Compton scattering due to the activity of the higher-energy radionuclide, corrections were made for this interference. Interference from higher-energy radionuclides not in the analysis scheme was not compensated for in the calculations and, if present, would cause the radionuclide concentrations reported to be somewhat higher than the true value.

For determining the gross alpha and gross beta activity of water, a 500-ml aliquot of a sample previously gamma-scanned was evaporated to dryness on a 2-inch planchet and counted in a gas-flow internal proportional counter utilizing a two-inch detector. The minimum detectable gross beta activity is approximately 10 pCi/liter; the limit for gross alpha analyses is less than 1 pCi/liter. The gross alpha and beta results are not corrected for decay since the concentrations of specific alpha- and beta-emitting radionuclides were not known. Due to the high concentrations of dis-

Table 1. Summary of radioactivity in water samples, Columbia River study

(Concentrations in pCi/liter)

Location and number of samples	Value	Gross Beta		^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	$^{103}Ru+$ ^{106}Ru	^{51}Cr
		Suspended	Dissolved					
Umatilla (1)		23	158	<170	86	<13	15	11,000
Arlington (3)	Min.	<10	115	<170	<35	<13	<10	8,400
	Ave.	12	151	134	105	<13	12	9,146
	Max.	19	215	233	157	<13	15	9,600
John Day Dam (2)	Min.	<10	115	<170	<35	<13	<10	5,800
	Ave.	<10	135	<170	<35	<13	<10	8,050
	Max.	11	155	<170	<35	<13	<10	10,300
Rooster Rock (14)	Min.	<10	15	<170	<35	<13	<10	1,175
	Ave.	14	63	<170	42	<13	<10	3,438
	Max.	34	205	267	75	<13	13	5,760
Goble (12)	Min.	<10	<10	<170	<35	<13	<10	800
	Ave.	12	54	<170	<35	<13	<10	2,078
	Max.	34	141	238	43	15	<10	3,550
Beaver Army Terminal (12)	Min.	<10	13	<170	<35	<13	<10	1,029
	Ave.	15	53	<170	35	<13	<10	2,439
	Max.	51	84	<170	81	<13	<10	4,670
Astoria (12)	Min.	<10	22	<170	<35	<13	<10	600
	Ave.	<10	[a] 48	<170	<35	<13	<10	1,614
	Max.	27	380	175	37	<13	16	2,480
Ft. Stevens (1)		<10		184	<35	<13	<10	<100
Tillamook Bay (11)	Min.		800	<170	<35	<13	<10	<170
	Ave.		[b] 810	<170	<35	<13	<10	<170
	Max.		820	284	<35	<13	<10	408

[a] Saltwater samples not included in average.
[b] Average of 2 samples.

solved solids, sea water samples were omitted from the alpha and beta analyses.

Results

The gross alpha activity for all water samples collected between August 1963 and July 1964 was below the minimum detectable concentration of 1 pCi/liter. The gross beta activity concentrations in the Columbia River water samples are summarized in table 1. In general, the concentrations were observed to decrease with increasing distance from the Hanford reactors (see figure 2). In addition, the data tended to confirm the expected decrease in concentrations during the summer months because of high dilution as the result of the increased summer flows in the Columbia River. All concentrations were below the maximum permissible concentrations recommended by the International Commission on Radiological Protection (*5*). For water from all dietary sources, the following ICRP standards are given for the population at large: ^{65} Zn, 10,000 pCi/liter; ^{95} Zr–^{95} Nb, 20,000 pCi/liter; ^{103} Ru, 27,000 pCi/liter; and ^{51} Cr, 670,000 pCi/liter.

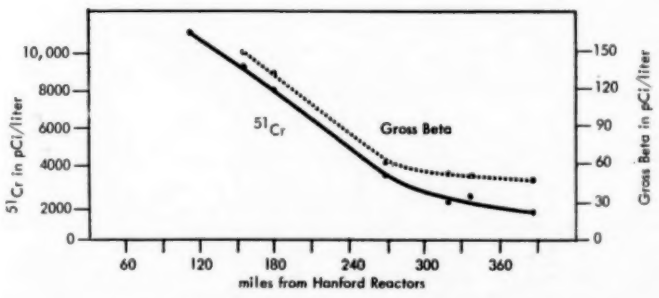

Figure 2. Average gross beta and chromium–51 concentrations in Columbia River water, August 1963–July 1964

Columbia River bottom sediments were found to contain comparatively high levels of radioactivity (table 2). Since radionuclide concentrations are dependent upon the characteristics of the sediment, the sediments collected were arbitrarily classified into different types and numbered 2 to 5, fine to coarse for aiding in the intercomparison of data.

The neutron activation radionuclide zinc–65 was observed in readily detectable concentrations in the biological samples collected: algae (table 3), and shellfish (table 4) shown in figures 3 to 6. Although these data represent significant concentrations of zinc–65, the amount consumed by the general public resulting from eating these shellfish would be far below the

maximum permissible intake.Use of the guides, recommended by the International Committee on Radiation Protection for total body exposure for the general population, implies a permissible intake rate of 8 x 10^6 pCi/year for zinc–65. Considering the average concentration of zinc–65 in crab and oysters during this period (15 pCi/gram), the permissible intake

Table 2. Summary of radioactivity in sediment samples, Columbia River study

(Concentrations in pCi/gram wet or drained weight)

Location	Number of Samples	Usual sed. type	Value	^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	^{103}Ru+ ^{106}Ru
John Day Dam	2		Min.	15.8	2.5	0.4	<0.1
			Ave.	16.0	4.6	0.5	0.3
			Max.	16.2	6.7	0.6	0.5
Arlington	2	5	Min.	28.9	28.3	1.3	1.4
			Ave.	31.0	31.4	1.8	1.6
			Max.	33.0	34.5	2.2	1.7
Rooster Rock	13	5	Min.	12.9	0.9	0.2	0.2
			Ave.	15.6	11.2	1.4	0.6
			Max.	20.8	36.0	8.1	1.4
Goble	12	5	Min.	12.8	1.2	0.3	0.2
			Ave.	21.1	22.4	2.0	1.0
			Max.	54.5	99.6	6.7	3.9
Beaver Army Terminal	10	5	Min.	11.3	3.4	0.4	0.3
			Ave.	19.2	22.2	2.0	1.4
			Max.	41.1	128.0	8.2	7.7
Astoria	8	3	Min.	9.8	1.5	0.5	0.7
			Ave.	16.2	19.6	4.2	1.6
			Max.	25.0	42.3	11.0	3.6
Ft. Stevens	1		Min.				
			Ave.	10.8	0.3	0.3	0.1
			Max.				
Tillamook Bay	9	3	Min.	9.0	0.1	0.3	0.2
			Ave.	11.2	0.3	2.1	0.8
			Max.	13.3	0.6	6.1	2.1

Table 3. Summary of radioactivity in algae samples, Columbia River study

(Concentrations in pCi/gram wet or drained weight)

Location	Algae type	Number of samples	Value	^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	^{103}Ru+ ^{106}Ru	^{51}Cr [a]
Goble	*Cladophora* species	10	Min.	25.5	22.3	<0.17	0.2	710
			Ave.	43.3	88.2	6.9	4.2	1,230
			Max.	89.2	160.5	17.4	10.4	1,680
Goble	Green attached moss	2	Min.	39.4	93.4	1.1	2.2	
			Ave.	40.9	106.8	4.6	4.1	
			Max.	42.4	120.1	8.0	6.0	
Beaver Army Terminal	*Cladophora* species	10	Min.	18.9	37.5	3.3	1.8	480
			Ave.	32.8	54.0	7.8	3.3	1,203
			Max.	63.7	135.0	15.7	6.9	1,620
Astoria	*Cladophora* species	7	Min.	6.6	7.3	0.6	0.5	250
			Ave.	18.9	27.5	8.4	2.3	950
			Max.	35.7	45.9	32.0	7.0	1,550
Fort Stevens	*Zostera marina*	1	Min.					
			Ave.	9.6	1.2	1.6	0.1	2.8
			Max.					
Tillamook Bay	*Zostera marina*	5	Min.	1.8	0.1	0.6	0.2	
			Ave.	2.8	0.2	1.5	0.4	
			Max.	3.4	0.4	2.4	0.5	
Tillamook Bay	*Fucus furcatus*	6	Min.	4.7	0.2	0.2	0.2	
			Ave.	6.3	0.3	0.8	0.4	
			Max.	9.8	0.7	1.3	0.7	
Tillamook Bay	*Enteromorpha compressa*	2	Min.	2.9	0.3	0.3	0.2	
			Ave.	4.9	0.4	0.6	0.4	
			Max.	6.9	0.6	0.9	0.6	

[a] Three samples.

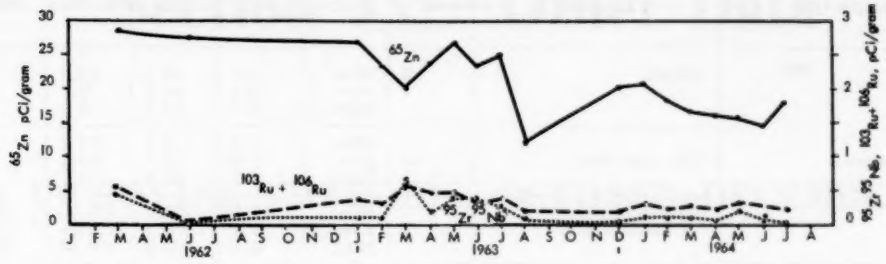

Figure 3. Concentrations of radionuclides in Dungeness crab collected at Astoria

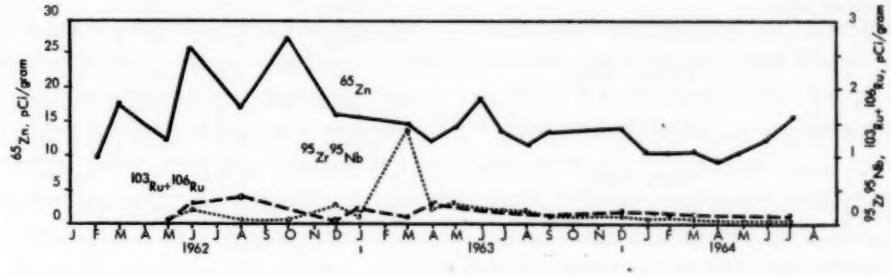

Figure 4. Concentrations of radionuclides in Dungeness crab collected at Tillamook Bay

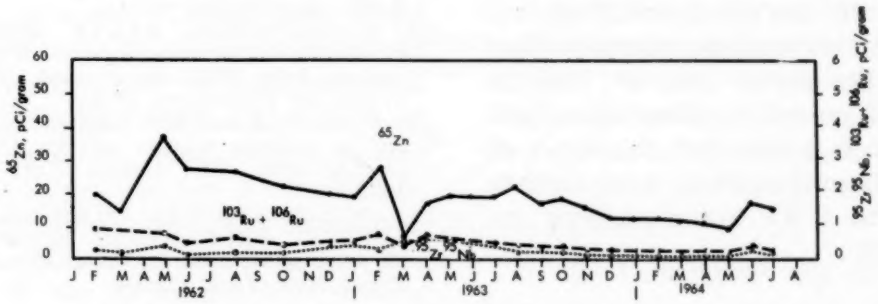

Figure 5. Concentrations of radionuclides in Pacific oysters collected at Tillamook Bay

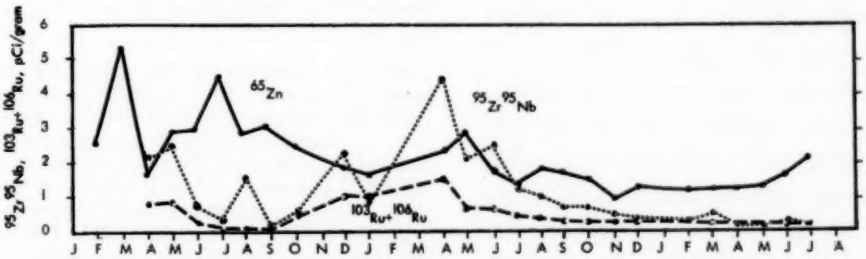

Figure 6. Concentrations of radionuclides in soft shell clams collected at Tillamook Bay

Table 4. Summary of radioactivity in shellfish samples, Columbia River study

(Concentrations in pCi/gram drained weight)

Sample type	Location	Number of Samples	Value	^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	$^{103}Ru+$ ^{106}Ru
Dungeness crab	Astoria	9	Min.	1.1	12.2	<0.1	0.1
			Ave.	2.1	16.9	0.1	0.2
			Max.	3.0	20.7	0.2	0.3
	Tillamook Bay	10	Min.	1.2	9.4	<0.1	0.1
			Ave.	1.8	12.1	<0.1	0.2
			Max.	2.2	16.1	0.2	0.2
	Alaskan Southern Coastal Area [a]	2	Min.	1.9	<0.2	<0.06	<0.04
			Ave,	2.1	<0.2	<0.06	<0.04
			Max.	2.3	<0.2	<0.06	<0.04
Pacific oysters	Tillamook Bay	[b] 11	Min.	1.3	9.6	<0.1	0.2
			Ave.	2.1	14.6	0.1	0.3
			Max.	3.2	22.1	0.3	0.4
	Yaquina Bay	1		1.5	2.3	<0.1	<0.1
Razor clams (*Siliqua* species)	Seaside	1		3.9	23.8		
Soft shell clams (*Mya arenaria*)	Tillamook Bay	11	Min.	1.8	0.9	0.1	0.1
			Ave.	2.7	1.4	0.4	0.3
			Max.	3.5	2.1	1.0	0.4
Mussels (*Mytilus*)	Cannon Beach	1		2.9	20.0	0.2	0.4
	Nehalem River Jetty	2	Min.	2.8	17.1	0.2	0.5
			Ave.	3.0	18.6	0.2	0.5
			Max.	3.3	20.2	0.2	0.5
	Agate Beach	1		2.0	5.0	<0.1	0.3
Snails (*Thais*)	Nehalem River Jetty	1		3.0	41.5	0.3	0.6

[a] This data has been added for the purpose of comparison.
[b] Three samples.

of 8 x 10^6 pCi/year would be reached only after consuming in excess of 1,000 pounds of these shellfish over the period of one year.

In summary, the radionuclide concentrations measured during the period August 1963 to July 1964 required no action other than continued surveillance to insure that the levels of radioactivity in this environment were neither too high relative to ICRP standards nor increasing too rapidly.

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Recent coverage in *Radiological Health Data:*

Period	Issue
January 1962—July 1963	*August 1964*

Section IV—Other Data

IODINE-131 IN BOVINE THYROIDS, OCTOBER–DECEMBER 1964

Edmond J. Baratta,[1] *Edward R. Williams,*[2] *and George Murray*[3]

To supplement existing environmental radiation surveillance systems, the Division of Radiological Health established a bovine thyroid collection and analysis system on a regular network basis in the fall of 1964. Iodine–131 levels in bovine thyroids were previously investigated in a pilot study (*1, 2*). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The network consists of collection areas (figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear testing sites. In addition, most of the bovine thyroid sampling areas overlap the milksheds serving the metropolitan areas participating in the Pasteurized Milk Network (*3*), and are near a station of the Radiation Surveillance Network (*4*). The thyroid sampling program is designed to permit intercomparison with the data from these two networks.

Thyroid specimens are generally obtained from dairy cows which have been found to be either brucellosis or tuberculosis reactors and are therefore being sent to slaughter. For such animals, a history of their recent forage is readily available, and they are usually killed within 2 to 3 days after leaving the dairy farm. Where such specimens are not available, thyroids from "cutters and canners" cattle are used. These animals are also usually slaughtered near the areas in which they have grazed.

Sample collection and analysis

As they become available at slaughter houses, the thyroids are placed in small glass vials (containing paraformaldehyde), and are shipped to the Northeastern Radiological Health Laboratory. Accompanying each sample is a tag containing information on the age of the cow, area from which she came, and the date of slaughter.

At the Laboratory, the samples are assayed for iodine–131, using a 3– x 3–inch NaI(Tl) well crystal and a multichannel gamma spectrometer. A sample changing unit permits the automatic counting of 100 samples, with the data recorded on a punched-tape read-out. Since counting efficiency varies with sample volume, each sample is weighed and this weight is used to estimate the counting efficieny. The iodine–131 activity is calculated in terms of picocuries per gram of thyroid and corrected for decay back to noon of the slaughtering date. For purposes of quality control, 10 percent of the samples are analyzed a second time and, for those samples containing significant activity (i.e., above 50 pCi/g), decay curves are plotted.

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[2] Mr. Williams was Laboratory Coordinator, Division of Radiological Health, Public Health Service, DHEW, Washington, D.C., during this investigation.

[3] Dr. Murray is Staff Officer for Procedures and Requirements, Meat Inspection Division, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C.

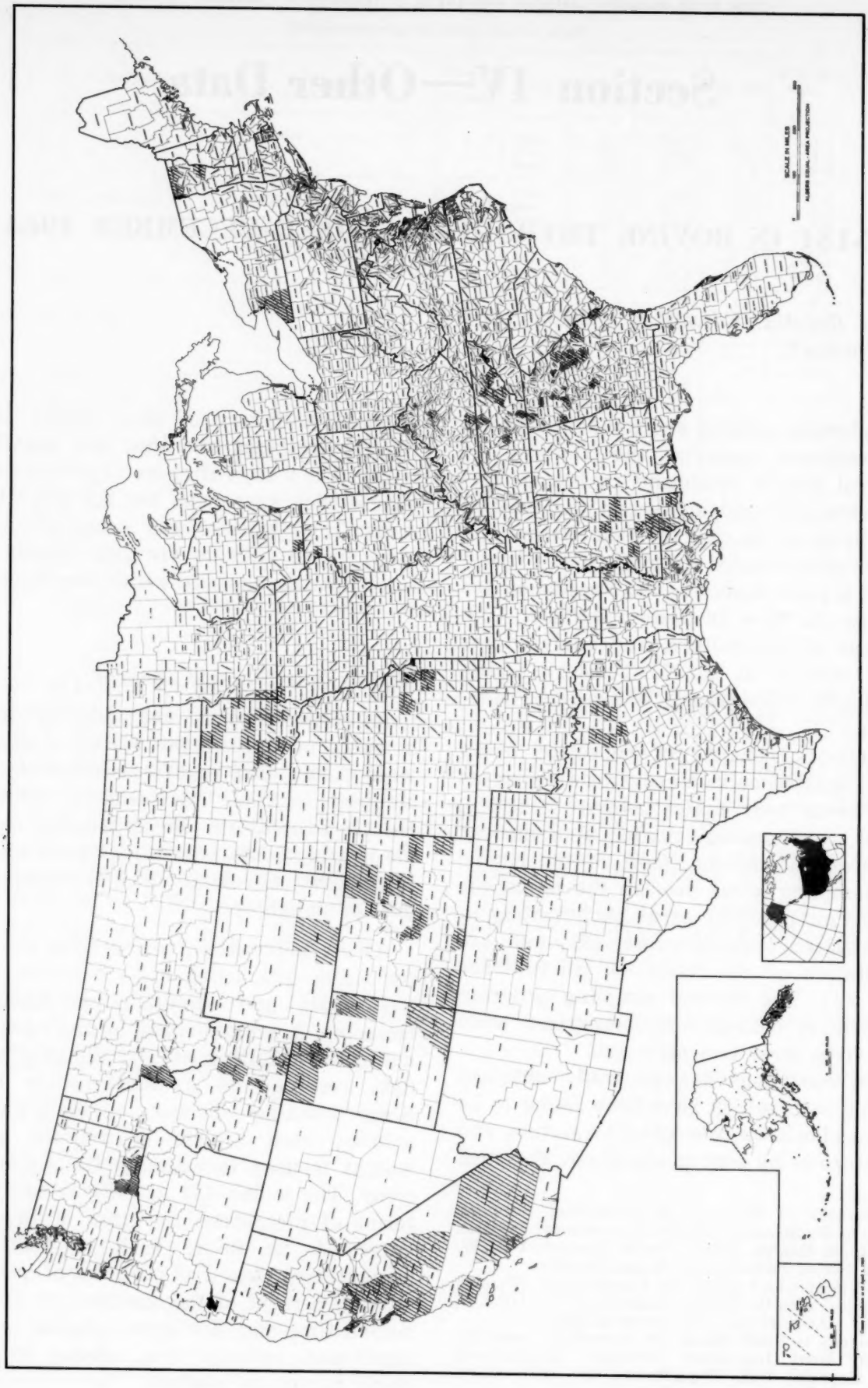

Figure 1. Sample collection areas for the bovine thyroid network

Table 1. Iodine-131 in bovine thyroids

Origin by State and county	Date of slaughter (1964)	Approximate age or range of ages, years	Iodine-131, pCi/g thyroid	Counting error [a]
Calif:				
Los Angeles	11/6	3–4	[b]	(2)
	11/19	6	[b]	(2)
Orange	12/17	5–6	[b]	(2)
Fresno	12/21	4	[b]	(2)
San Joaquin	12/23	4	[b]	(1)
Colo:				
Arapahoe	11/11	[c]	55.80	2.26
	11/18	5	93.38	2.54
Boulder	11/11	4 y 6 mo	121.74	2.30
Chaffee	11/19	4	26.44	2.33
Cheyenne	11/6	4 y 6 mo	74.87	1.68
	11/6	4 y 10 mo	62.41	1.63
	11/6	4 y 6 mo	25.52	1.19
Conejos	11/10	9	28.54	1.62
	11/10	9	23.09	2.15
	11/10	9	23.08	1.43
Denver	12/3	3 y 6 mo	[b]	(1)
Elbert	10/21	2 y 6 mo	1.70	0.91
El Paso	11/25	4–7	[b]	(9)
	12/8	5 y 6 mo	10.31	4.40
Fremont	12/4	5	[b]	(1)
Logan	10/29	6 y 6 mo	2.98	1.96
Morgan	12/11	7	17.69	6.04
Prowers	10/23	6 y 4 mo	[b]	(3)
Unknown	10/28	7	0.96	0.52
Weld	11/13	4	57.77	1.78
	11/13	4	24.93	1.50
Ga:				
Effingham	11/2	6	1.85	0.73
	11/2	6	4.17	0.67
	11/2	7	3.25	0.57
	11/2	6	2.71	1.13
	11/2	7	1.23	0.80
	11/2	6	2.69	1.06
	11/2	6	3.97	0.82
	11/2	6	3.21	0.97
Fulton	12/2	6	[b]	(1)
	12/2	7	3.97	1.42
	12/2	7	6.10	0.92
	12/3	7	8.21	0.77
	12/3	5	5.25	1.18
Greene	11/21	10	1.14	0.74
Hancock	10/23	4	[b]	(1)
Haralson	11/13	9	35.33	1.53
Warren	11/12	6	35.78	1.58
Washington	11/27	6	11.65	1.42
Whitfield	11/13	4	23.24	1.27
	11/27	2 y 6 mo	11.56	1.26
	11/27	1 y 6 mo	24.42	1.55
Wilkes	10/23	6	[b]	(1)
	11/12	7	3.67	0.87
	11/19	8	14.93	1.10
	11/19	9	31.02	1.53
	12/3	2	17.19	1.04
	12/3	4	15.93	1.28
Idaho:				
Butte	11/17	7	13.58	0.83
Oneida	12/7	5	[b]	(1)
	12/7	5	10.37	4.52
	12/7	5	4.75	3.77
	12/7	5	9.50	4.21
Ill:				
Carroll	12/10	4	[b]	(1)
Iowa:				
Lyon	11/18	3	19.38	3.60
Kans:				
Douglas	10/29	4	12.14	1.73
Franklin	11/18	4	55.78	1.62
Osage	11/18	2	4.36	1.67
	12/23	3	2.72	1.11
Pottawatami	[c]	4	1.96	0.56
	[c]	5	2.17	0.32
	[c]	4	0.61	0.43
	[c]	6	[b]	(1)
Riley	12/23	3	[b]	(3)
Wyandotte	12/23	3	[b]	(3)
Ky:				
Wayne	12/2	4	11.31	1.99
	12/2	7	12.40	1.13
	12/2	6	7.99	1.15
	12/2	6	[b]	(1)
Miss:				
Forrest	10/9	6–7	[b]	(2)
	10/23	5–8	[b]	(4)
	10/26	6–10	[b]	(4)
	11/6	3 y 6 mo	28.11	1.54
	11/6	3 y 6 mo	25.66	2.87
	11/10	6	93.40	2.16
	11/10	8	88.96	2.45
	11/13	3 y 9 mo	35.25	1.65
	11/16	8 y 6 mo	31.36	1.61
	11/16	5 y 6 mo	39.25	1.78
	11/16	7	3.55	1.95
	11/16	8	17.58	1.28
	11/17	11	2.51	1.76
	12/1	2	8.46	1.49
	12/1	4	11.46	1.53
	12/7	6 y 6 mo	[b]	(1)
	12/8	7–14	[b]	(2)
	12/8	6	11.41	9.72
	12/9	3–9	[b]	(5)
	12/9	14	14.99	7.77
	12/9	14	15.02	9.44
	12/9	7	7.23	5.62
	12/9	12	12.39	9.81
	12/9	6	20.30	8.09
Jackson	10/6	3 y 6 mo	[b]	(1)
Lamar	10/6	4 y 6 mo	[b]	(1)
	11/10	8	4.74	1.14
	11/10	8	115.84	2.51
	11/10	10	37.73	1.61
	11/20	3	23.39	1.21
Leake	11/21	5 y 6 mo	20.69	1.59
Marion	10/19	6–9	[b]	(2)
	10/26	3	[b]	(1)
	11/10	7 y 6 mo	50.97	1.68
Newton	11/6	2 y 3 mo	30.05	1.64
N.Y:				
Cattaraugus	11/3	13	145.64	3.22
	11/3	11	0.44	0.72
	11/3	9	280.14	3.54
	11/3	10	39.06	2.06
	11/14	13	77.30	1.72
	11/14	13	82.38	2.75
	12/17	12–12 y 8 mo	[b]	(5)
	12/24	12–12 y 6 mo	[b]	(6)
	12/31	12	2.50	2.11
	12/31	12–12 y 8 mo	[b]	(6)
Chautauqua	10/28	9–10	[b]	(2)
	10/28	12	6.54	1.11
	10/28	14	82.45	1.66
	11/5	9	[b]	(1)
	11/5	10	14.45	1.11
	11/5	11	6.92	0.78
Erie	10/23	9	2.45	0.48
	10/23	10–13	[b]	(3)
	10/29	10	11.31	1.32
	10/29	10	31.22	1.65
	10/29	8	173.88	1.99
	11/5	12	34.02	1.72
	11/12	9	13.25	1.35
	11/12	11	49.07	1.13
	11/12	8	16.43	1.15
	11/12	10	28.22	1.49
	11/19	4	[b]	(1)
	11/19	8	10.33	1.02
	11/19	8 y 9 mo	8.32	1.06
	11/27	10	2.98	0.87
	11/27	3 y 6 mo	58.78	0.67
	11/27	5 y 6 mo	7.25	0.99
	11/27	8	[b]	(1)
	11/27	7	7.45	0.87
	11/27	5 y 4 mo	5.23	0.74
	12/3	8 y 6 mo	5.05	0.92
	12/3	9 y 9 mo	5.41	0.96
	12/3	7	6.21	0.36
	12/3	5	3.91	1.54
	12/3	8	1.16	0.77
	12/3	6	[b]	(1)
	12/3	9	3.41	3.41
	12/10	7	4.19	3.33
	12/10	8–12	[b]	(3)
Minn:				
Rock	11/3	8	34.51	0.97
Mont:				
Ravalli	11/18	6	12.97	1.15
S. Dak:				
Day	12/2	2	9.78	1.33
	12/2	2	10.21	2.25
	12/2	2	1.81	1.73
	12/2	2	1.78	1.15
	12/2	2 y 6 mo	6.42	2.03
	12/2	2	9.10	1.24
	12/2	1 y 6 mo	6.79	2.04
Deuel	11/18	9	[b]	(1)
Tenn:				
Blount	12/2	6	2.26	1.46
Bradley	11/27	5	16.45	1.26
	11/27	7	5.43	0.69
	11/27	8	10.92	0.79

Table 1. Iodine-131 in bovine thyroids—Continued

Origin by State and county	Date of slaughter (1964)	Approximate age or range of ages, years	Iodine-131, pCi/g thyroid	Counting error [a]
Tenn: (Continued)				
Bradley	12/2	6	15.71	1.86
	12/2	6	29.60	1.27
	12/2	7	22.80	1.40
Knox	12/2	6	3.23	0.89
Union	12/2	7	29.10	1.56
Tex:				
Dallas	12/4	9	[b]	(1)
Johnson	11/12	4	[b]	(1)
	11/12	5	4.43	1.30
Parker	10/21	4–6	[b]	(5)
Utah:				
Box Elder	11/7	5	[b]	(1)
	11/7	5	4.26	0.79
Cache	11/12	5	27.89	1.39
	11/12	5	15.35	1.24
	11/12	5	[b]	(1)
	11/12	5	19.00	0.94
	11/12	5	12.18	0.97
	11/12	5	35.52	1.71
	11/12	5	17.21	1.26
	11/12	5	27.52	1.53
	11/13	5	[b]	(2)
	11/13	5	1.09	0.85
	11/13	5	1.09	0.98
	11/14	4	38.33	1.71
	11/14	4	40.53	1.57
	11/14	4	46.41	1.53
	11/14	4	28.61	1.07
	11/14	4	31.47	0.96
	11/14	4	48.34	1.33
	12/3	5	[b]	(2)
	12/9	5	[b]	(1)
Vt:				
Orleans	12/17	6	[b]	(1)
Wash:				
Benton	11/19	5 y 5 mo	[b]	(2)
	11/19	4	4.35	1.33
	11/19	5	9.76	1.68
	11/19	5	17.51	2.03
Walla Walla	12/14	4	2.00	1.93
	12/14	5	2.55	3.28
	12/14	3	5.01	1.93
	12/14	5	4.07	3.23
	12/31	5	7.72	2.73
	12/31	4–7	[b]	(8)
	12/31	5	3.99	3.61
	12/31	5	4.51	3.46
Wis:				
Green	11/14	6	49.52	2.04
	11/16	3	1.80	0.98
	11/16	3	31.59	1.81
	11/16	3	22.72	1.59
	11/16	3	21.35	1.50
	11/16	3	30.22	1.85
	11/16	8	13.84	1.10
	11/16	3	50.10	1.95
	11/16	3	7.87	1.31
	11/16	3	3.15	1.13
	11/16	3	3.04	1.26
	11/16	5	18.09	1.29
	11/16	5	10.62	1.40
	11/16	3	25.21	1.37
	11/16	6	6.16	1.92
	11/16	6	14.09	1.27
	11/16	3	13.88	1.18
Ozaukee	11/12	7	63.48	1.93
	11/12	7	77.25	2.29
Wyo:				
Carboa	12/8 [d]	4	7.77	0.73

[a] Two standard deviations. Number of samples shown in parentheses.
[b] Observed value equal to or less than 2σ counting error.
[c] Information not available, iodine-131 reported as of date counted (11/4/64).
[d] Date counted.

Results and conclusions

Data reported in this paper include those values obtained from October through December 1964, a period during which iodine–131 contamination was observed in many areas of the United States, presumably as a result of the atmospheric detonation of a nuclear device on the Chinese mainland on October 16, 1964. Iodine–131 levels in thyroids collected during this period are recorded in table 1. For the sake of brevity, complete data are given for only those samples having iodine–131 concentrations above the minimum detectable level (above 2σ level). For samples containing less than the minimum detectable level, only the number of specimens is given. In addition, the weights of the indivdual samples have also been omitted. In general they ranged from 10 to 15 grams each.

Figures 2–5 show concentrations of iodine–131 in thyroids during the October–December interval for four selected locations in Colorado, Georgia, New York, and Mississippi. These graphs also show the daily levels of gross beta radioactivity in air (*5*), and the weekly concentrations of iodine–131 in fluid milk samples

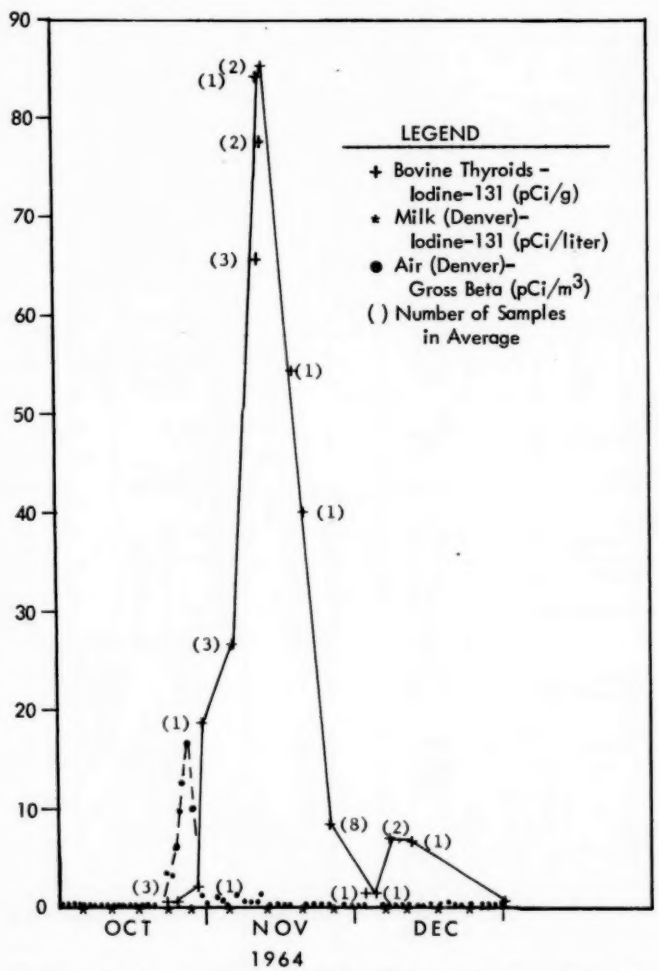

Figure 2. Appearance of iodine–131 in bovine thyroids, fall 1964, Colorado

as reported to the Radiation Surveillance Center, Division of Radiological Health (*3*).

The Colorado, Georgia, and New York air and milk samples were collected in the same general area where the cows foraged before being sent to slaughter, but the Mississippi air and milk samples were collected in Jackson (located in the central portion of the State), while the thyroids were obtained from cows which had been on farms in the vicinity of Hattiesburg (located near the southern part of the State, about 95 miles from Jackson).

In the case of the pasteurized milk data, Atlanta failed to show any increase to detectable levels and in the other three cites (Buffalo, Denver, and Jackson) the increases were only minimal (*i.e.*, up to a maximum of 20 picocuries per liter). Had the sampling frequency of the milk network been greater, it is possible that the intrusion would have been more clearly indicated. Considering that the intrusion was essentially a single contaminating event, it is interesting to note that the effective half life of the iodine–131 in the thyroids in all four locations ranged from about 3 to 6 days. This closely parallels previously reported data for the half-time of this nuclide in the milk after deposition on pasture under similar conditions (*6*).

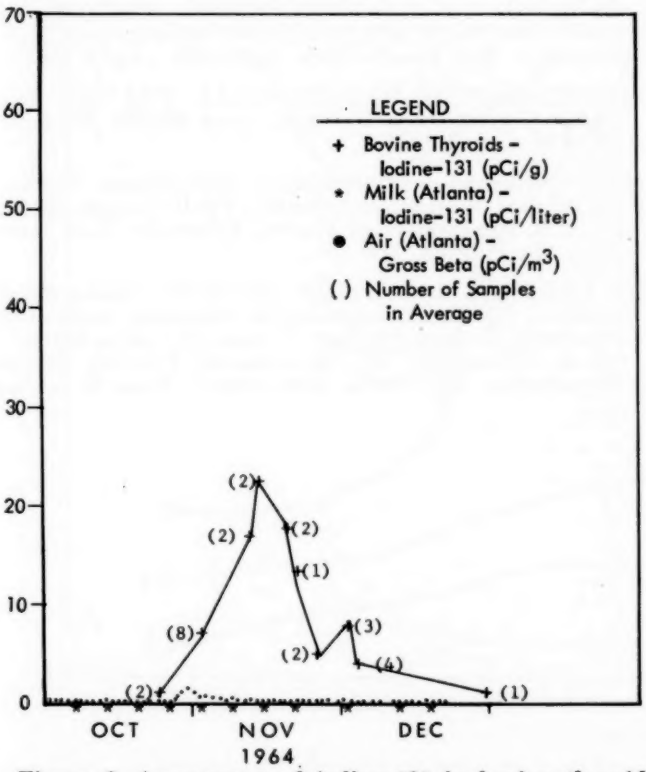

Figure 3. Appearance of iodine–131 in bovine thyroids, fall 1964, Georgia

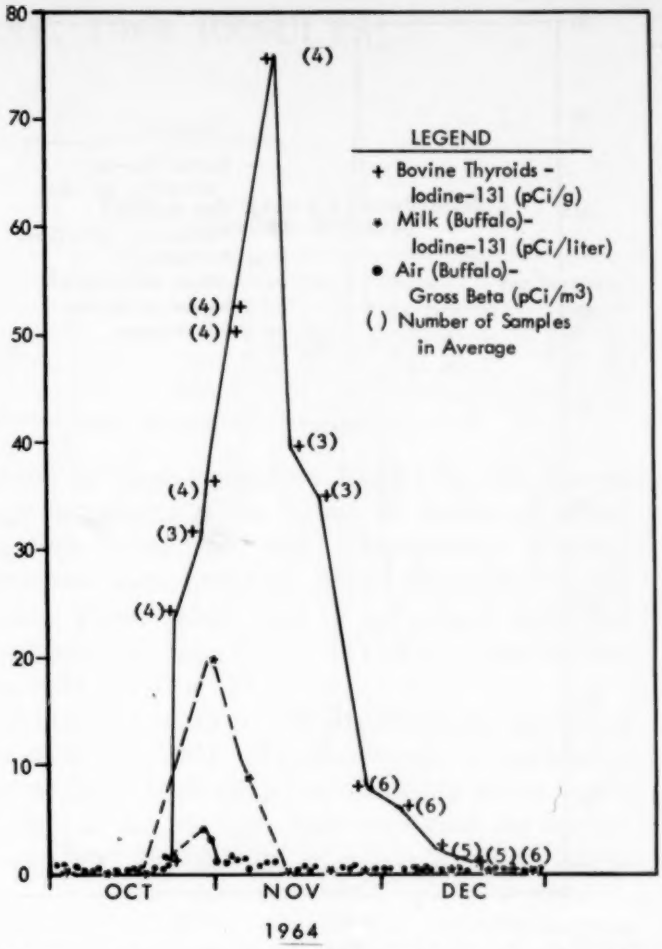

Figure 4. Appearance of iodine–131 in bovine thyroids, fall 1964, New York State

On the basis of these data, it can be concluded that the collection and analysis of bovine thyroids is an extremely sensitive method for the detection of environmental iodine–131 intrusions. Although this approach is not as quick in its response as the determination of radioactivity levels in air, it is specific for this radionuclide and, in that sense, it is an excellent supplementary environmental assessment tool.

Although the data are limited, several facts are evident. In all four of the plotted locations, the intrusion was clearly delineated by the thyroid data. At every location there was also some increase in air radioactivity levels prior to the detection of iodine–131 in the thyroids. For Denver, the increase was very pronounced; for Atlanta, it was barely detectable. In this regard, it is pointed out that the air data shown are those obtained through counting the filter-trapped particulates in the laboratory. The field estimates of gross beta activity in these same samples showed considerably more scatter. Regardless of whether the laboratory or

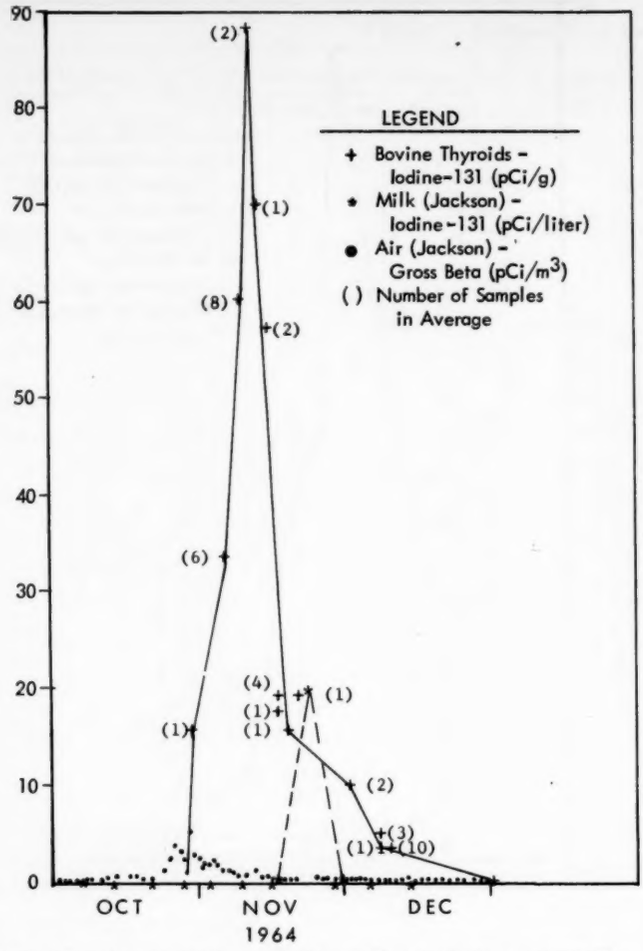

Figure 5. Appearance of iodine–131 in bovine thyroids, fall 1964, Mississippi

field air data were used, however, with the possible exception of Denver, the intrusion was much less clearly delineated by the air data than by the thyroid data.

In the case of the pasteurized milk data, Atlanta failed to show any increase to detectable levels and in the other three cities (Buffalo, Denver, and Jackson) the increases were only minimal (*i.e.*, up to a maximum of 20 picocuries per liter). Had the sampling frequency of the milk network been greater, it is possible that the intrusion would have been more clearly indicated. Considering that the intrusion was essentially a single contaminating event, it is interesting to note that the effective half life of the iodine–131 in the thyroids in all four locations ranged from about 3 to 6 days. This closely parallels previously reported data for the half-time of this nuclide in the milk after deposition on pasture under similar conditions (*6*).

On the basis of these data, it can be concluded that the collection and analysis of bovine thyroids is an extremely sensitive method for the detection of environmental iodine–131 intrusions. Although this approach is not as quick in its response as the determination of radioactivity levels in air, it is specific for this radionuclide and, in that sense, it is an excellent supplementary environmental assessment tool.

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STRONTIUM-90 IN HUMAN VERTEBRAE, 1964 RESULTS[1]

Joseph Rivera [2]

Since 1961, the Health and Safety Laboratory (HASL) has been obtaining specimens of human vertebrae for strontium–90 analyses in New York City, Chicago, and San Francisco. The specimens are from accident victims or from individuals whose metabolism and diet can be assumed to have been normal prior to sudden death. The results of analyses of samples obtained in 1964 are summarized in table 1; details of results are shown in tables 2–4.

Where there were a sufficient number of samples at each age to make valid comparisons, the highest strontium–90 concentrations were found in bones from New York City, the lowest concentrations were found in bones obtained in San Francisco, and intermediate concentrations were found in bones obtained in Chicago. These results are in agreement with the findings of the HASL Tri-City diet strontium–90 studies (*1*).

Table 1. Average pCi strontium-90/g calcium in vertebrae

Age (years)	New York City	Chicago	San Francisco
0–4	[a] 5.99 (23)	1.95 (1)	2.65 (42)
5–19	3.07 (33)	3.26 (5)	1.66 (27)
20 and over	2.02 (25)	1.45 (43)	1.23 (11)

[a] Parentheses indicate number of samples

Since the start of the HASL bone sampling program in 1961, 212 specimens of vertebrae from New York City residents, up to 20 years of age at death, have been analyzed for strontium–90. The results of these analyses were

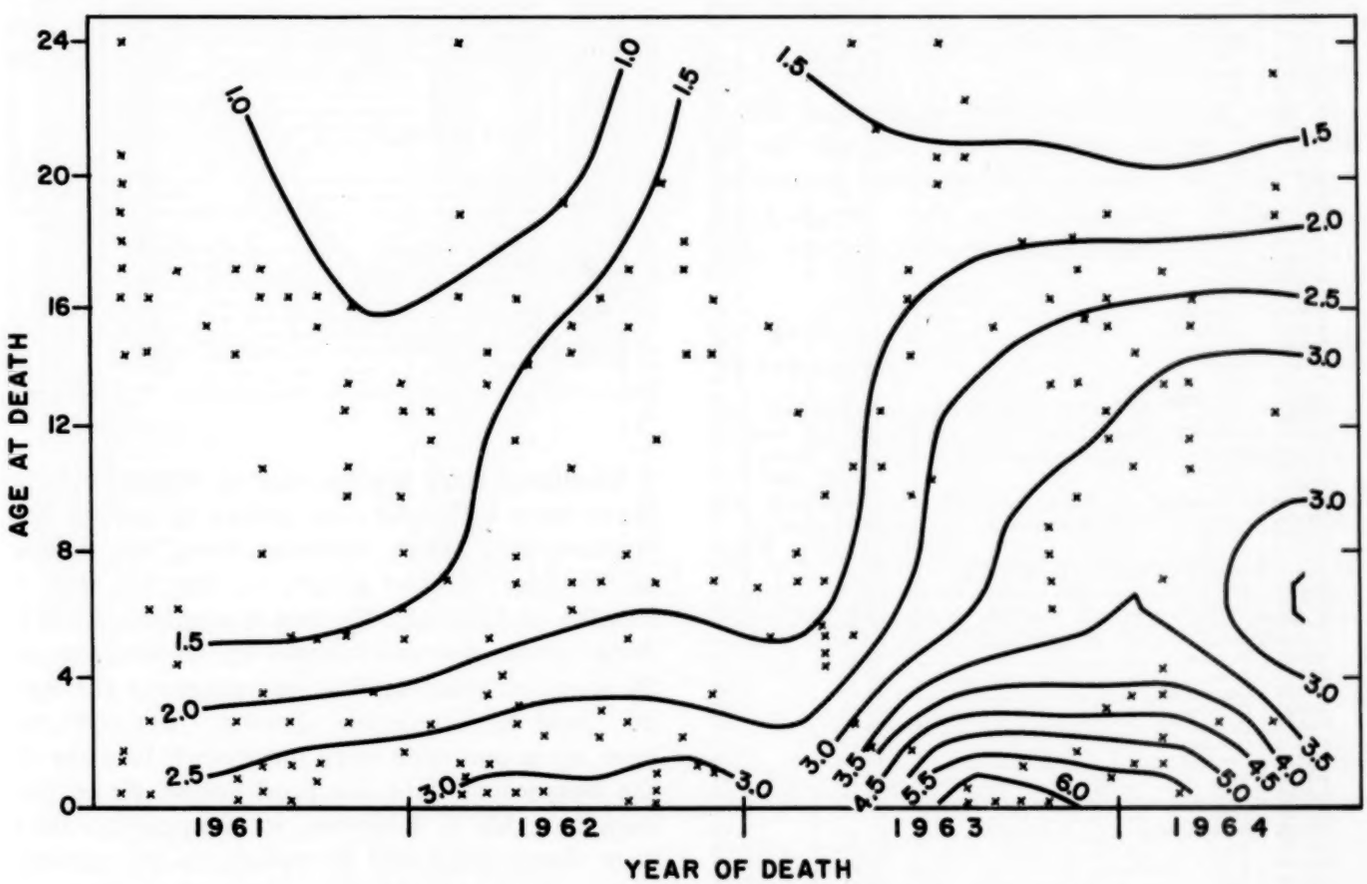

Figure 1. Isopleths of strontium–90 (pCi/g Ca) in New York City vertebrae

[1] Summarized from *Fallout Program Quarterly Summary Report*, HASL—161:296–306. Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151 (July 1, 1965). Price $4.00.

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used to construct figure 1, using a standard numerical approximation program for a digital computer.

From figure 1, the variation of strontium–90/calcium ratios with age (*i.e.*, highest levels for young children and lower levels for adults) that has been noted previously (*2*), is quite apparent. In addition, the general increase with time in strontium–90 levels for indviduals of all ages, associated with increased diet strontium–90/calcium ratios starting in early 1963 (*3*), is also readily seen.

Table 2. Strontium-90 in human vertebrae New York City, 1964

HASL No.	Date of death	Age	pCi/g Ca
B3036	January	3 mo.	7.40
B3054	January	1 mo.	7.40
B3057	February	3 mo.	7.40
B3102	April	11 mo.	9.94
B3103	April	7 mo.	9.94
B3157	May	4 mo.	7.11
B3164	May	5 mo.	7.11
B3169	May	9 da.	7.11
B3151	May	1 wk.	6.19
B3155	May	11 mo.	6.19
B3043	January	18 mo.	5.10
B3167	May	18 mo.	5.38
B3140	June	18 mo.	5.10
B3313	September	18 mo.	4.19
B3055	February	30 mo.	4.40
B3096	March	24 mo.	4.40
B3142	June	24 mo.	8.30
B3158	June	30 mo.	6.76
B3090	April	3 yr.	1.90
B3315	August	3 yr.	5.48
B3298	October	3 yr.	2.26
B3162	May	4 yr.	5.40
B3139	June	4 yr.	3.32
B3147	June	5 yr.	2.69
B3041	February	6 yr.	2.55
B3061	February	7 yr.	2.88
B3161	May	7 yr.	4.79
B3051	February	8 yr.	4.02
B3143	June	8 yr.	3.15
B3047	February	9 yr.	4.92
B3049	February	10 yr.	3.19
B3097	March	11 yr.	2.55
B3154	May	12 yr.	4.48
B3321	July	12 yr.	4.04
B3092	April	13 yr.	2.34
B3225	July	13 yr.	4.07
B3100	April	14 yr.	3.06
B3326	October	14 yr.	2.73
B3048	February	15 yr.	3.06
B3095	March	15 yr.	2.72
B3148	June	15 yr.	3.61
B3312	July	15 yr.	3.82
B3163	May	16 yr.	2.46
B3098	March	17 yr.	2.79
B3108	April	17 yr.	3.00
B3227	July	17 yr.	3.15
B3371	November	17 yr.	2.94
B3058	February	18 yr.	2.81
B3053	February	18 yr.	2.56
B3060	February	18 yr.	3.83
B3101	April	18 yr.	2.72
B3319	July	18 yr.	2.10
B3367	December	18 yr.	2.30
B3104	March	19 yr.	1.77
B3105	March	19 yr.	1.65
B3150	June	19 yr.	2.77
B3038	January	20 yr.	2.05
B3099	March	20 yr.	1.61
B3373	November	20 yr.	2.65
B3106	April	21 yr.	1.47
B3322	October	21 yr.	2.11
B3330	October	22 yr.	1.67
B3372	October	26 yr.	1.35
B3032	January	33 yr.	1.62
B3307	October	36 yr.	2.08
B3304	October	37 yr.	2.70
B3301	October	37 yr.	1.54
B3327	October	38 yr.	1.22
B3141	June	42 yr.	1.77
B3320	September	41 yr.	1.89
B3305	October	45 yr.	2.07
B3303	October	48 yr.	1.31
B3302	October	48 yr.	1.40
B3310	October	49 yr.	1.73
B3165	May	50 yr.	2.94
B3146	June	60 yr.	2.10
B3159	June	67 yr.	1.97
B3308	September	65 yr.	2.49
B3160	May	70 yr.	3.92
B3149	June	75 yr.	2.39
B3228	July	88 yr.	2.38

Table 3. Strontium-90 in human vertebrae, Chicago, 1964

HASL No.	Date of death	Age, yrs.	pCi/g Ca
B3295	December	3.5	1.95
B3283	July	5	5.40
B3362	November	5	3.51
B3290	November	15	2.30
B3123	March	17	1.69
B3293	November	17	3.40
B3086	March	22	1.50
B3284	May	23	1.19
B3219	August	25	1.98
B3274	August	28	2.65
B3082	March	29	1.48
B3083	March	30	1.14
B3137	June	31	1.51
B3272	August	35	2.38
B3360	September	35	2.27
B3217	October	35	1.78
B3084	March	37	1.02
B3081	April	39	0.87
B3224	August	39	2.78
B3218	August	40	1.62
B3270	June	42	1.05
B3135	July	42	1.35
B3085	March	43	0.53
B3128	March	43	0.81
B3220	April	43	1.99
B3279	June	43	0.99
B3112	April	44	1.03
B3131	June	44	1.27
B3223	August	44	1.46
B3110	March	45	1.37
B3111	March	45	1.06
B3138	June	45	0.97
B3271	July	46	0.54
B3363	July	46	1.66
B3134	July	47	1.81
B3133	May	49	1.64
B3136	June	49	1.24
B3119	March	50	1.89
B3028	March	56	0.87
B3266	October	57	1.51
B3122	March	63	1.32
B3025	March	64	1.66
B3109	March	69	1.43
B3024	March	76	0.94
B3114	March	78	1.76
B3026	March	82	1.26
B3126	March	83	1.43
B3089	March	88	1.42
B3030	March	97	1.75

Contours were drawn only in regions where there were sufficient data points to justify the construction. Thus contours were not drawn at the edges of the graph, *i.e.* for the first 6 months of 1961 and the last 6 months of 1964. Data points for individuals up to the age of 25 were included so that the contours for age 20 could be accurately drawn. Contours for ages up to one year were not drawn because of the absence of data for fetal bones. From the data in table 1, however, it is apparent that very sharp gradients in strontium–90/calcium ratios occurred in this age interval in 1964.

Table 4. Strontium-90 in human vertebrae, San Francisco, 1964

HASL No.	Date of death	Age	pCi/g Ca
B3258	May	1 da.	1.34
B3262	May	1 da.	2.71
B3291	May	1 da.	2.71
B3251	May	2 da.	2.32
B3234	October	2 da.	2.71
B3069	March	4 da.	2.52
B3017	March	8 da.	1.96
B3015	January	10 da.	1.96
B3240	October	2 wk.	3.14
B3334	January	3 wk.	1.19
B3333	October	3 wk.	1.19
B3239	August	1 mo.	2.71
B3238	September	1 mo.	2.71
B3230	September	2 mo.	2.71
B3241	September	2 mo.	3.14
B3281	May	2 mo. 15 da.	2.71
B3165	March	3 mo.	2.52
B3088	March	3 mo.	2.71
B3064	February	4 mo.	2.52
B3246	May	4 mo.	2.32
B3254	May	4 mo.	4.44
B3244	June	4 mo.	2.71
B3337	November	4 mo.	3.38
B3259	July	6 mo.	1.34
B3018	March	7 mo.	2.71
B3255	May	7 mo.	4.44
B3014	January	11 mo.	1.96
B3336	November	11 mo.	3.38
B3013	February	12 mo.	2.90
B3249	April	12 mo.	6.49
B3256	June	12 mo.	2.44
B3179	July	12 mo.	3.05
B3264	October	12 mo.	2.44
B3201	March	14 mo.	3.65
B3067	February	18 mo.	2.91
B3177	February	18 mo.	2.12
B3229	October	24 mo.	1.98
B3068	February	24 mo.	2.90
B3235	February	24 mo.	2.90
B3087	April	36 mo.	1.95
B3077	January	3 yr.	2.09
B3232	September	3 yr.	1.55
B3070	February	5 yr.	2.86
B3071	March	5 yr.	1.41
B3342	December	5 yr.	2.51
B3260	July	6 yr.	1.61
B3012	January	6 yr. 6 mo.	1.29
B3205	January	7 yr.	2.24
B3211	May	7 yr.	1.37
B3213	August	7 yr.	1.71
B3251	May	7 yr.	2.90
B3079	February	8 yr.	1.10
B3198	June	8 yr.	1.72
B3184	June	10 yr.	1.63
B3009	February	10 yr.	0.98
B3237	September	11 yr.	1.39
B3183	August	13 yr.	2.33
B3346	December	13 yr.	2.00
B3020	March	14 yr.	0.88
B3261	May	14 yr.	1.43
B3248	May	14 yr.	1.08
B3181	April	15 yr.	1.57
B3011	January	16 yr.	1.48
B3231	October	16 yr.	1.31
B3192	March	17 yr.	0.40
B3196	June	17 yr.	1.46
B3006	January	18 yr.	0.98
B3190	August	18 yr.	3.87
B3240	October	18 yr.	1.19
B3002	January	20 yr.	1.22
B3180	February	20 yr.	1.32
B3172	June	20 yr.	1.40
B3008	January	22 yr.	1.62
B3005	January	23 yr.	1.18
B3001	January	45 yr.	1.06
B3007	February	45 yr.	1.22
B3000	January	47 yr.	0.81
B3010	February	51 yr.	1.08
B3003	July	51 yr.	1.46
B3004	January	73 yr.	1.17

In HASL–146 it was shown that the increases in the strontium–90 content of adult vertebrae from 1962 to 1963 could be predicted from the observed diet levels in 1963, assuming a bone-diet observed ratio of 0.25 and an annual bone turnover rate of 9 percent per year. The equation describing the relationship is:

$$x_n = x_{n-1} - fx_{n-1} + fkz_{n-1}$$

where x_n is the average strontium–90/calcium ratio observed in year 'n', x_{n-1} is the average ratio observed during the previous year, f is the annual bone turnover rate, k is the bone-diet observed ratio, and z_{n-1} is the average $^{90}Sr/Ca$ ratio of the diet during the year n–1.

Using estimates of z_{n-1} from the Tri-City Diet studies, and 1964 estimates of x_{n-1} from HASL–146, gives:

New York City

$$x_n = 1.55 - (.09)(1.55) + (.09)(.25)(32)$$
$$= 2.13 \qquad \text{(observed } x = 2.02\text{)}$$

Chicago

$$x_n = 1.11 - (.09)(1.11) + (.09)(.25)(20)$$
$$= 1.46 \qquad \text{(observed } x = 1.45\text{)}$$

San Francisco

$$x_n = 0.94 - (.09)(0.94) + (.09)(.25)(14)$$
$$= 1.18 \qquad \text{(observed } x = 1.23\text{)}$$

The agreement between calculated and observed strontium–90/calcium ratios in adult vertebrae indicate the validity of the bone sampling as well as the accuracy of the Tri-City diet strontium–90 estimates.

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(*3*) U.S. ATOMIC ENERGY COMMISSION. Daily intake of strontium–90 in New York City, Chicago and San Francisco. Atomic Energy Commission Report No. HASL–161:215, fig. 8. (July 1, 1965).

PROJECTED VALUES OF CESIUM-137 BODY BURDENS IN ANAKTUVUK PASS ESKIMOS FOR THE SUMMER OF 1965, BASED ON FINDINGS IN CARIBOU MUSCLE[1]

James R. Coleman[2]

The discovery of relatively high levels of fallout radionuclides in arctic ecosystems has stimulated interest both nationally and internationally (*1, 2*). The first studies related to radionuclides in Alaskan ecosystems began in 1959 in connection with Project Chariot (*3, 4*). After the finding of high levels of cesium–137 in lichens and caribou, the studies were extended in 1962 to include whole body counting of Eskimos (*5*). This report describes a method for predicting values of body burdens that might be expected in Anaktuvuk Pass Eskimos and to present the estimated values for the summer of 1965. The data used are the cesium–137 whole body counting data reported for a control group of 21 adult Anaktuvuk Pass inhabitants (*5, 8, 9, 11*), and the concentration of cesium–137 in caribou flesh obtained as part of the cooperative program between the State of Alaska and the Public Health Service (*6, 7*).

Among the facts that have emerged from the Alaskan studies are:

1. The people of the interior village of Anaktuvuk Pass have consistently shown the highest average body burdens of cesium–137 (*3, 9*) among Alaskan peoples.
2. There is a definite seasonal variation in body burdens in individuals from this village. The highest body burdens observed have occurred during July and the lowest, during the winter months (*9*).
3. The average body burdens of the inhabitants of Anaktuvuk Pass appear to be directly related to the amounts of cesium–137 in caribou (*9*).

Because of the growing interest in fallout radionuclides as related to Anaktuvuk Pass villagers and the importance of anticipating future body burdens, this attempt has been made to devise methods by which one might, with reasonable accuracy, project current data forward in time in order to arrive at estimates of the cesium–137 body burdens that might be experienced by the inhabitants of Anaktuvuk Pass at some future time. Although general long-term predictions have been made by others (*10*), this report is limited to short-term projections.

The method proposed evaluates the available data in terms of simplified considerations and is not intended to define basic biological parameters or ecological situations. The lack of definitive and complete biological and ecological information can be overcome only by additional study.

Model and assumption

The predictive equation represents a model which must include basic assumptions related to local ecology and native habits. These assumptions are by necessity simplifications, made in order to supplement the available data. Four basic simplifying assumptions have been made in this analysis, and are as follows:

1. The accumulation of cesium–137 in both caribou and man can be characterized by a single-compartment exponential model.
2. The cesium–137 intake for caribou might, within reason, be characterized by a square wave. That is, the caribou intake may be considered to result from two rather distinct seasonal diet patterns.
3. During periods of low cesium–137 intake by the caribou, a base level of 0.7 nCi/kg would be reached in caribou flesh.
4. The dietary intake of cesium–137 of the Anaktuvuk villagers could be expressed as a square wave, related to two major periods of caribou slaughtering.

[1] Manuscript for this article, including the values shown in the text, was submitted to the Editorial Committee, Division of Radiological Health, July 6, 1965. Since this date, tentative data on the average cesium–137 body burdens of the Anatuvuk Pass control group, secured under the auspices of the Atomic Energy Commission on July 23–24, 1965 indicate good agreement of the projected values, with the actual values being somewhat lower.

[2] Mr. Coleman is Chief, Data Collation and Analysis Section, Radiation Surveillance Center, Division of Radiological Health, Public Health Service, Washington, D.C.

In general, these assumptions, although gross simplifications of complex factors, are considered to be reasonable as an initial approach. Cesium–137 retention (assumption 1) may be more accurately described by a multicomponent model (*12–14*). However, such a refinement would appear to be of little overall importance considering other inaccuracies inherent in the method used.

The second assumption, although more of a simplification than the first, may be rationalized primarily on the basis of changing seasons and the availability of forage. Inherent in this assumption is the selection of specific periods for the caribou diet changes related to the square wave function. Although seasons do not change abruptly, transitional periods, as related to feeding habits, may be relatively short. For this analysis the dates selected need not define actual dates of significant diet changes, but need only have a general relationship to the changing situation. Fortunately, this does not appear to be critical and must be predicted on the greatest extent on approximating the observed caribou data. Thus, the periods or dates of caribou diet changes selected represent a balanced average related to seasonal changes, but are inherently a function of the model and data themselves.

The third assumption, made solely to supplement existing data, was based on the consideration of two data points, one in October 1962 and the other in August 1964. It is difficult to say how close this assumption relates to the actual situation; however, since the levels in caribou flesh during these periods appear to be roughly an order of magnitude less than the levels during the high periods, an error in this assumption would not be greatly limiting. This assumption does not imply that the actual level of cesium–137 in caribou flesh is constant over the period of concern, but only that for the purpose of relating these levels to the intake by the Eskimos, they may be represented by a single value.

The fourth assumption is directly related to the caribou migration and thus the caribou killing and storage habits of the Eskimos. The migrations of the caribou in the central Brooks Range are very complex and are not well understood. However, from about early June until early August caribou are usually absent from the main valley at Anaktuvuk Pass (*15*). During the period of absence of caribou, the villagers utilize a store of previously killed caribou kept in underground caches. This storage of meat botained from the spring kill (period of high concentration of cesium–137 in caribou) supports, in part, the concept of a square-wave intake for the villagers. As with assumption two, there is inherent in this assumption a selection of exact periods or dates of diet change. Again, this selection is predicated primarily on fitting the observed data, and thus the dates selected can be considered only general periods, weighted by the data, but supported by a general knowledge of caribou hunting and storage habits.

Once the above assumptions have been made, one may proceed with an attempt to fit the available data to a projection model. The method used involved two steps: First, on the basis of assumption number one, an equation of the form shown below (equation 1) was fitted to the caribou data using the square wave intake pattern, and the result projected in time through the summer of 1965:

$$(1)\quad B_i = A_i\left[1-\exp\left(-\frac{0.693}{T_e}t_i\right)\right] + B_{i-1}\exp\left(-\frac{0.693}{T_e}t_i\right)$$

Where:
- T_e = Effective half life of cesium-137 in caribou muscle (days)
- t_i = Time interval of concern (consistent units with T_e)
- B_i = Level of activity in caribou muscle at end of time interval t_i (nCi/kg)
- B_{i-1} = Level of activity in caribou muscle at beginning of time interval t_i (nCi/kg)
- A_i = A factor relating to the caribou intake of cesium-137 over the period t_i (selected in a square wave pattern so that the available caribou muscle data might be reasonably approximated).

Second, using the estimated levels of cesium–137 in caribou muscle during the periods intermediate to actual sampling and related to the selected periods of human diet changes, the square wave intake pattern for the Eskimo was obtained. A similar equation (equation 2) was then fitted to the observed average body bur-

dens. Once reasonable relationships were set up, the average body burdens for the inhabitants were projected through the summer of 1965.

$$(2)\ \beta_i = \alpha I_i\left[1-\exp\left(-\frac{0.693}{\tau_e}t_i\right)\right] + \beta_{i-1}\exp\left(-\frac{0.693}{\tau_e}t_i\right)$$

Where:
- τ_e = Effective half-life of cesium-137 in population of concern (days)
- t_i = Time interval of concern (consistent units with τ_e)
- β_i = Body burden at end of time interval t_i (μCi)
- β_{i-1} = Body burden at beginning of time interval t_i (μCi)
- I_i = Intake concentration in caribou (nCi/kg)
- α = A constant relating to the Eskimo's intake of caribou (μCi per nCi/kg).

Results

The detailed curves arrived at for the concentration in caribou muscle and average body burden of the villagers are shown in figures 1 and 2, respectively. From figure 1, it may be seen that there has been an apparent decrease in the cesium–137 concentration in caribou muscle in March of this year as compared to the estimated value for March of 1964 (period selected for spring eskimo diet change). This, as shown in figure 2, would lead to slightly decreased body burdens in the summer of 1965 as related to the summer of 1964.

Using the curve presented in figure 2, the following comparison may be made between the estimated body burdens for the summer of 1964 and those projected for the summer of 1965:

	1964	1965
July 1	1.2μCi	0.88μCi
August 1	1.35μCi	0.94μCi

The average body burdens over specified time periods is also of interest for comparison to existing guidance. Since a reasonably continuous function has been fitted to the data, average

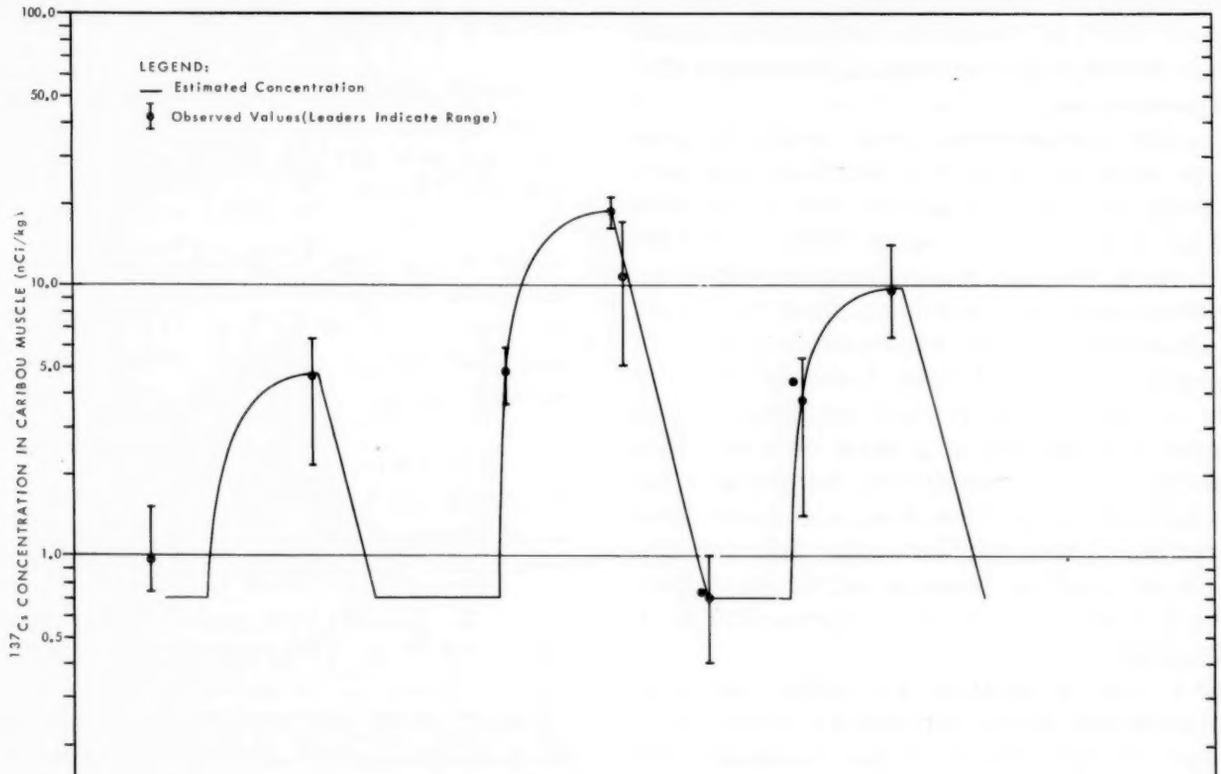
LEGEND:
Estimated Concentration
Observed Values(Leaders Indicate Range)
100.0
50.0
10.0
5.0
1.0
0.5
0.1
137Cs CONCENTRATION IN CARIBOU MUSCLE (nCi/kg)
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M
1962 1963 1964 1965 1966

Figure 1. Projected and observed cesium–137 concentrations in caribou muscle for Anaktuvuk Pass area

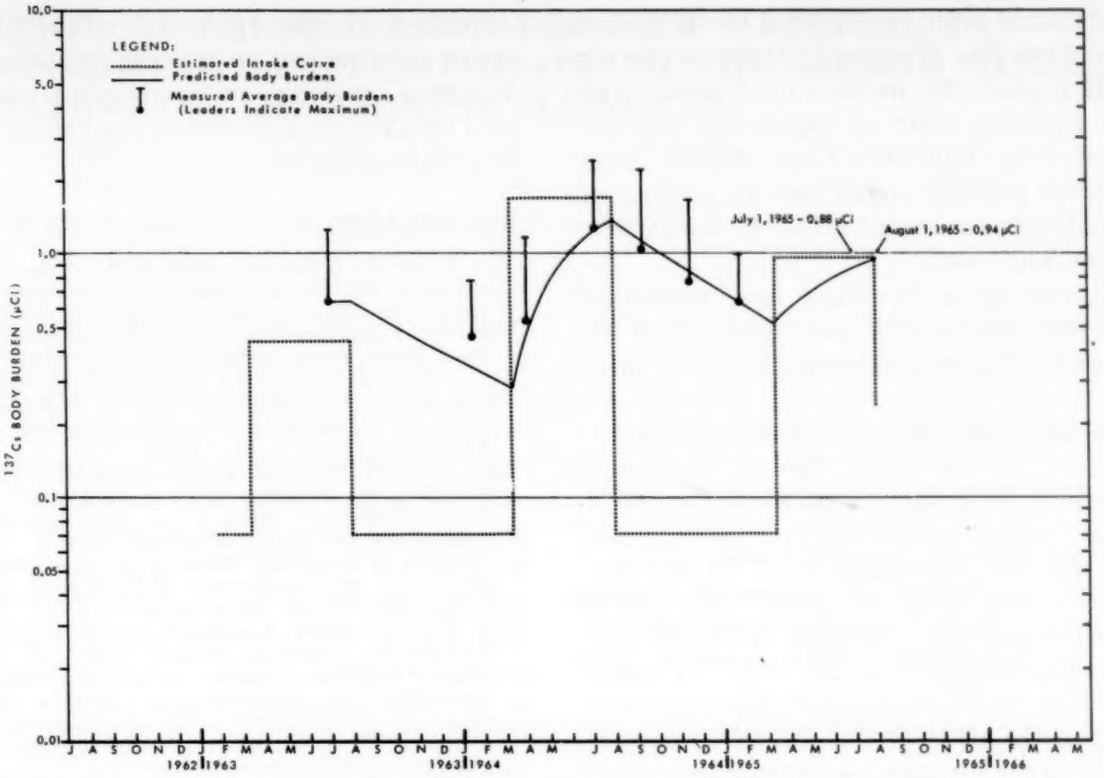
LEGEND:
Estimated Intake Curve
Predicted Body Burdens
Measured Average Body Burdens
(Leaders Indicate Maximum)
July 1, 1965 - 0.88 μCi
August 1, 1965 - 0.94 μCi
137Cs BODY BURDEN (μCi)
10.0
5.0
1.0
0.5
0.1
0.05
0.01
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M
1962 1963
1963 1964
1964 1965
1965 1966

Figure 2. Body burden and estimated intake curves for Anaktuvuk Pass villagers

body burdens over various time periods may be mathematically calculated from the curve shown in figure 2. The following annual averages have been obtained:

	1964	1965
Annual average body burden for adult villagers	0.82μCi	0.70μCi

Discussion

From figure 1, it may be observed that the caribou muscle data may be reasonably described by the method used and the assumption made. In order to apply the equation presented, an effective half-life for cesium–137 in caribou muscle under range conditions had to be selected. By consideration of the data obtained during the year 1964, the effective half-life was approximated to be 26 days. Although this value should not be considered as representing true biological half-life, it is in reasonable agreement with values observed in other animals (*16–18*). The dates arrived at for changes of caribou intake (early May for the spring diet change and early December for the winter diet change), although not completely consistent with the change of seasons, are also not totally unreasonable.

The curve obtained for estimated average body burdens presented in figure 2, together with the observed measurements, shows the relatively close agreement between the actual values and the fitted equation. In only one instance (January 1964) did the estimated values differ from the measured values by more than 15 percent. This is also the one period for which data were lacking for the concentration of cesium–137 in caribou muscle. Since the effective half-life of cesium–137 in the individuals counted cannot be obtained from the data, equation 2 was fitted to the average body burden using various effective half-lives. Figure 2 is derived by using a value of 140 days which appeared to give the best fit. This value for the effective half-life in man, while somewhat greater than might at first be expected, is not grossly inconsistent with reported values (*19*).

It should not be implied that this value represents the actual effective half-life in the individuals concerned, it should be considered as a mathematical parameter that has been used to suitably represent the data.

At this point, it is important to discuss the effect of the assumption of a base level of 0.7 nCi/kg of cesium–137 in caribou flesh during the late summer and fall seasons. If this as-

sumption is not valid, and actual levels in caribou, and thus the Eskimo's intake, were significantly higher, the method used would yield a fitted equation with a somewhat overestimated effective half-life. Thus, higher levels during these periods might tend to give an effective half-life somewhat closer to the 100-day value generally used.

In attempting to evaluate how reasonable our analysis and results are, some short discussion of the factor a in equation 2 is of interest.

In general a may be expressed as follows:

$$a = \frac{cfw}{\lambda}$$

where: c = Proportionality factor
f = Fraction of cesium-137 ingested that is deposited in the body
λ = Effective decay constant (days -1)
w = Daily intake (kg/day)

solving for the daily intake w, yields

$$w = \frac{a\lambda}{cf}$$

The value for a obtained from the fitted equation was 0.142. The fraction f is estimated to be 1.0 (*2, 21*). Using these values we can estimate the daily intake suggested by the observed value of a. The calculation yields a daily intake of 0.703 kg/day.

This value can be compared with the 0.772 (kg/day) value for caribou intake reported by Hanson *et al.* (*5*) as an estimate for the summer of 1962.

Conclusions

Although a number of generalizing assumptions have been made, it can be concluded that, on the basis of available data, the model devised yields reasonably accurate approximations to the observed data, and should allow anticipation of the resultant average body burdens in Anaktuvuk villagers on the basis of cesium–137 concentration in caribou muscle. It may also be concluded that expected body burdens will be somewhat lower in July and August of 1965 than those observed in July–August of 1964.

The average body burdens of the adult Anaktuvuk Pass villagers for the summer of 1965 is estimated to be approximately 0.9 μCi. At present it is not possible to say whether the apparent decreasing trend will continue. As more information on specific ecological factors becomes available, more accurate assumptions and further refinements in the model presented should be possible.

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DETECTION OF FRESH FISSION PRODUCT MATERIAL IN ENVIRONMENTAL SAMPLES FOLLOWING THE SECOND NUCLEAR DETONATION ON THE CHINESE MAINLAND

Division of Radiological Health, Public Health Service

On May 13, 1965 (10 p.m. EST) a second nuclear detonation occurred on the mainland of China. The test was believed to have taken place in the vicinity of Lop Nor in northwest China and was equal to or greater in yield than the first detonation that occurred in October 1964 (*1*). As with the first test, fresh fission products were observed by the Division of Radiological Health's routine environmental monitoring systems following the second test. The purpose of this summary is to report the extent to which fresh debris was observed in the Radiation Surveillance Network (RSN), the Pasteurized Milk Sampling Network (PMN) and the Bovine Thyroid Sampling Network of the Division of Radiological Health during May and June 1965.

Air

According to the 30,000 to 40,000-foot cloud trajectory developed by the Atmospheric Radioactivity Research Branch, United States Weather Bureau, the leading edge of the debris cloud passed the west coast of the United States on May 18 and the east coast by May 19 (*2*). Although early field estimates did not show any immediate significant increases in gross beta radioactivity, subsequent gamma analysis identified fresh fission products (iodine–132, tellurium–132, iodine–131, barium–140 and lanthanum–140) and the activation product neptunium–239 in many of the RSN's air samples.

The highest gross beta activity in air during the month of May for the United States was approximately 16 pCi/m^3 at Salt Lake City, Utah, for the sample collected May 20–21.

Fresh fission products were, however, first detected in the Helena, Montana, sample collected on May 18–19 (approximately 5 days after the detonation). Filters removed the following morning from most RSN stations in the Western United States contained identifiable fresh fission products in very low concentrations. The exceptions were those stations located on the Pacific coast. Except for the Pacific coast stations and several stations in the southeastern United States, at least one sample from each RSN station showed identifiable fresh fission products by May 24. From May 19–31, fresh fission products were identified on 87 RSN filters. During the month of June, fresh fission products were identified on 266 filters. In summary, the observation of the influx of fresh fission product material in air was generally consistent with the projected trajectory of the debris cloud, with the initial influx observed about May 18–20, and the peak air activity occurring somewhat later as might be expected.

Milk

Iodine–131 was not detected in any Pasteurized Milk Network (PMN) sample until May 24. However, since only one sample per week is routinely collected at each station, iodine–131 may have been present in milk several days prior to this date. Iodine–131 was detected on May 24 in only two samples; Honolulu, Hawaii, and Rapid City, South Dakota. Between May 24 and May 31, iodine–131 was found in measurable quantities in 19 samples from the PMN (*3*). During the month of June, 126 PMN samples contained detectable quantities of iodine–131 (page 539 of this issue). The highest concentration of iodine–131 observed was 220 pCi/liter for the sample collected on May 28 at Kansas City, Missouri.

Isograms showing the iodine–131 concentrations in milk for the weeks of May 23 and May 30 are shown in figures 1 and 2, respectively. The highest concentrations occurred in the Midwest, particularly in Missouri and Iowa. Only a few positive iodine–131 determinations were observed along the west coast and the southwestern and southeastern United States. By the end of June, iodine–131 was below detectable levels at most stations.

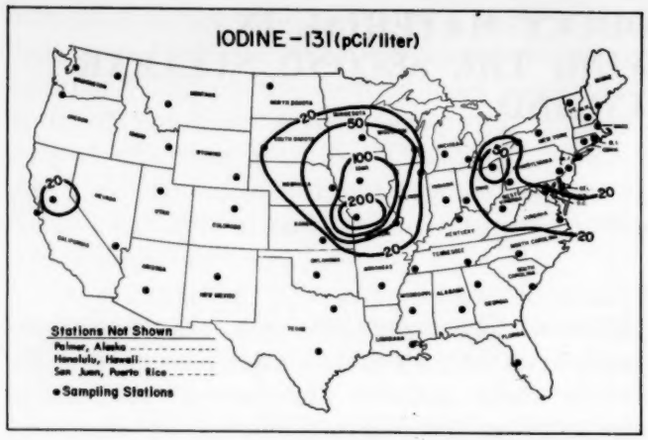

Figure 1. Iodine–131 concentrations in pasteurized milk, May 23–29, 1965

Bovine thyroid

During the months of May and June 1965, iodine–131 was found in measurable quantities in approximately 500 bovine thyroids collected as part of the Division of Radiological Health Surveillance Program. The highest activity observed in a single thyroid was approximately 2,000 pCi/gram in a thyroid collected on June 8 in the State of Iowa. The average value for eight thyroids collected in Iowa on this day was 821 pCi/gram.

Because of the relatively small number of thyroids collected on any one day in any single area, it is difficult to relate the levels of iodine

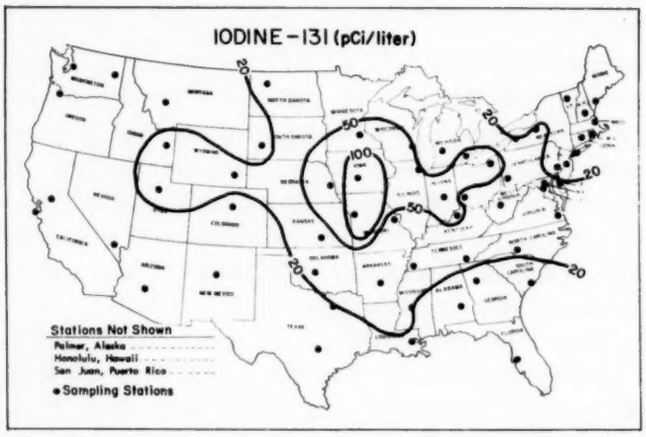

Figure 2. Iodine–131 concentrations in pasteurized milk, May 30–June 5, 1965

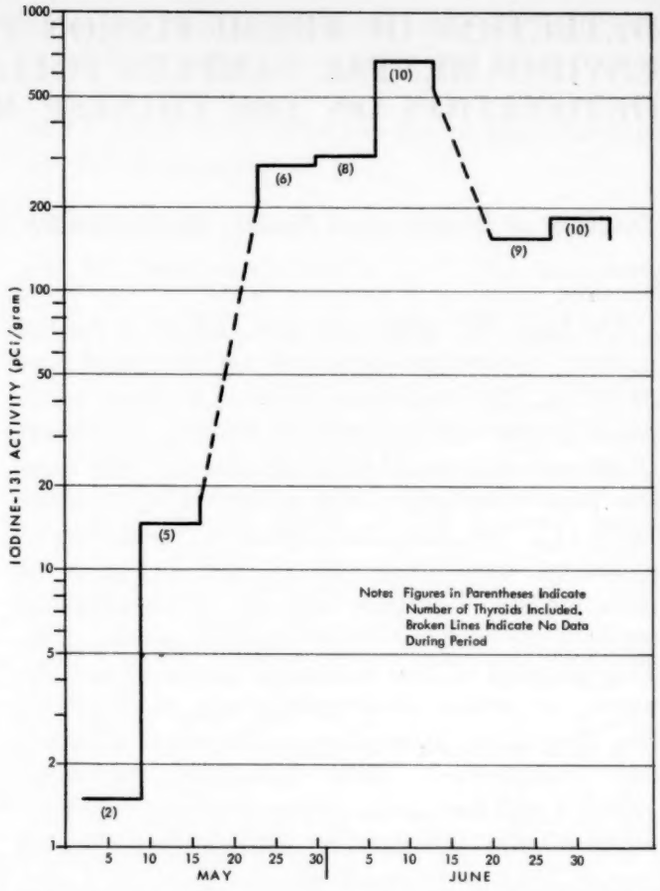

Figure 3. Weekly average levels of iodine–131 in bovine thyroids from South Dakota and Iowa, May–June 1965

in thyroid to the changing levels of iodine observed in other environmental media. However, the data may be grouped to show general trends following the influx of iodine–131 into the environment. Figures 3, 4, and 5 show the weekly average levels of iodine–131 in bovine thyroids for several grouped States. The data for California have been plotted separately in order to show the relative sensitivity of the bovine thyroid as an indicator of environmental iodine–131. Although only one milk sample collected in California by the PMN showed measurable iodine–131, the low level intrusion was readily documented by the bovine thyroid analysis. In general, the observations of iodine–131 in bovine thyroids were consistent with observations of iodine–131 in milk. The highest average levels were observed in the Midwest and lowest average levels in California.

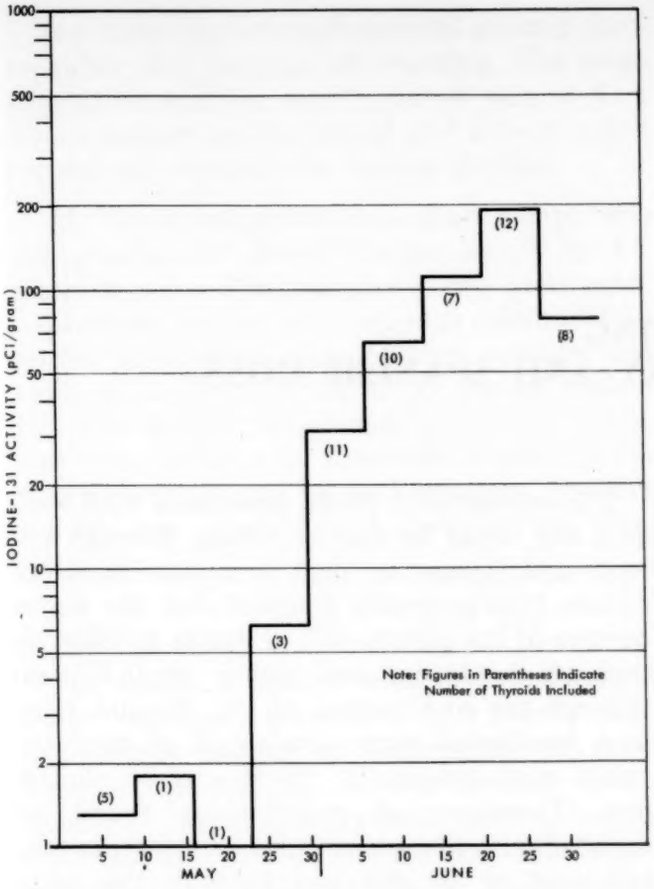

Figure 4. Weekly average levels of iodine–131 in bovine thyroids from California, May–June 1965

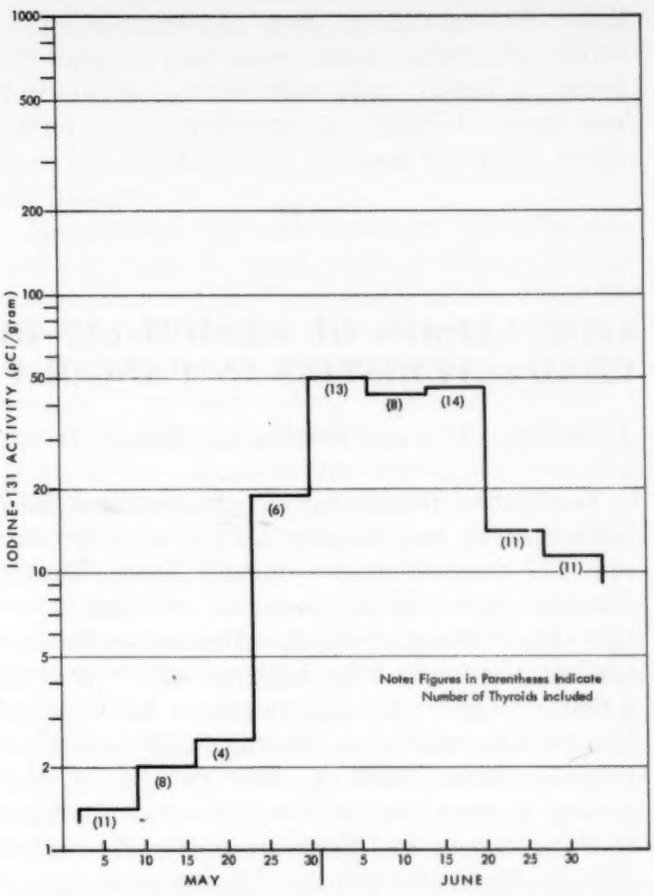

Figure 5. Weekly average levels of iodine–131 in bovine thyroids from New Mexico, Texas, and Colorado, May–June 1965

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COMPARISON OF CESIUM-137 BINDING CHARACTERISTICS IN PANGOLA HAY AND SPANISH MOSS

Robert L. Elder and Wellington Moore, Jr.[1]

The Public Health Service Pasteurized Milk Network has consistently shown that the cesium–137 concentrations in milk from Tampa, Florida, were higher than the national average (*1*). Although not requiring any protective actions, the levels were high enough to prompt a field survey by the Southeastern Radiological Health Laboratory to determine the contributory ecological factors. The results of this survey showed that cesium–137 concentrations in Pangola hay and Spanish moss were higher than in other plants in the Tampa area (*2*). It was further shown that elimination of Pangola hay from the diet of dairy cows in the Tampa area resulted in a decrease in the amount of cesium–137 in the milk (*2*). Having isolated Pangola hay as a factor contributing to the observed cesium–137 concentrations, analyses were undertaken to determine binding characteristics involved. For this purpose, Pangola hay was compared to Spanish moss. Pangola hay is a rooted grass grown in the Southern States, particularly Florida. Spanish moss is a non-rooted plant and is not routinely used as a dairy cattle feed.

The identification and isolation of particular types of vegetation which introduce high amounts of radioactivity into the food chain of animals and man is required. However, the presence of high levels of radioactivity in a plant that is used in the food chain does not necessarily constitute a direct hazard. The introduction into the food chain requires both presence and release during the process of digestion and absorption.

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The radioactivity found associated with Pangola hay could be due to uptake through the roots and foliage, or exist as surface contamination. It is generally accepted that the major portion of the cesium–137 in plants is taken up through the leaves, and only a small amount through the root system (*3*, *4*). Spanish moss as a non-rooted plant obtains all of its nutritional requirements by direct surface absorption. Therefore, all radioactivity found associated with this plant exists as a surface contaminant or is absorbed through the plant surface. In these preliminary studies we compared the location, binding and release of radioactive fallout particles from these two plants.

Procedures

(a) The Pangola hay was obtained from a farm located in the Tampa, Florida area. The Spanish moss was collected in the vicinity of Montgomery, Alabama.

(b) *Water washing*—Light water washing was accomplished by lightly spraying uncut hay or moss with water for three hours. Submerged water washing was done following cutting, grinding in a blender, and sifting through 18- x 14-mesh screen. The object of this grinding was to destroy as much of the plant cell structure as possible. A 500 gram sample was submerged and soaked in 3.5 liters of water for two hours. The samples were then filtered through Whatman 40 filter paper, and the wash water was passed back over the sample four times. The samples were air dried at room temperature to correspond to the unwashed samples.

(c) *Counting*—A multichannel gamma spectrometer was used for all counting. The large vegetative samples were counted with a 4- x 4-inch sodium iodide crystal and a 1- x 1-inch crystal was used for the isotope studies.

(d) *Ionic isotope binding*—Each sample was cut, ground and sifted through an 18- by 14-mesh screen. The samples were thoroughly washed and packed in 1- x 5-inch columns with fritted glass filters. The isotopic solution was applied directly to the top of the packed column followed by 100 ml of distilled water, which was collected at 5 ml intervals. Following the water elution a 100 ml KCl gradient (0–.5N) elution was applied and collected at 5-ml intervals.

Results

The results in table 1 indicated that a light water washing (equivalent to a heavy rain) removed 66 percent of the cesium–137 from Pangola hay, but less than 10 percent of the cesium–137 from Spanish moss. Similar results are presented in table 2 for the submerged water washing of ground samples. These results indicated that practically all of the cesium–137 on Pangola hay existed as a surface contaminant. The higher percent removal of cesium–137 in the submerged washing of Spanish moss was due most likely to the breakdown of cell structure by the grinding process.

The cerium–144 and ruthenium–106 levels for Pangola hay were below detectable limits. Both of these nuclides were found in much higher concentrations in Spanish moss and were not substantially released by either washing process.

Managanese–54 was found in both Pangola hay and Spanish moss. Light washing did not remove this nuclide from either plant (table 1). However, the submerged washing of ground samples showed a substantial reduction of this nuclide from both plants (table 2). Again it appeared that this removal was due to a breakdown of the cell structure during the grinding process. This would facilitate the release of internally bound nuclides in contast to surface bound contaminants.

Attempts to increase the efficiency of radionuclide removal by washing both plants with a 0.5N KCl solution did not substantially change the results (table 2). These findings indicated that Spanish moss had a very active inorganic ion binding mechanism. This is further supported by water washing results discussed in the preceding paragraph.

However, the cesium–137 of Pangola hay appeared to be almost totally on the surface of the plant. In the latter case any active binding is at best quite weak, for a considerable amount of this nuclide was removed by light washing.

The results of further studies to demonstrate the nature and site of the inorganic ion binding

Table 1. Removal of radioactive fallout by light water washing

	Cesium-137				Cerium-144				
	Pangola hay		Spanish moss			Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining		pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	3,100	100	2,480	100	Unwashed	<15	—	1,385	100
Washed	1,070	34	2,260	91	Washed	<15	—	1,275	92
	Ruthenium-106				Manganese-54				
	Pangola hay		Spanish moss			Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining		pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	<15	—	1,300	100	Unwashed	983	100	1,000	100
Washed	<15	—	1,220	94	Washed	925	94	815	81

Table 2. Removal of radioactive fallout by submerged water washing

	Cesium-137				Cerium-144				
	Pangola hay		Spanish moss			Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining		pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	3,100	100	2,260	100	Unwashed	<15	—	1,275	100
0.5N KCl Washed 1 x	1,030	33	1,360	60	0.5N KCl Wash 1 x	<15	—	942	74
Water Washed 1 x	977	31	1,490	66	Water Washed 1 x	<15	—	925	73
Water Washed 2 x	472	15	1,070	48	Water Washed 2 x	<15	—	845	66
	Ruthenium-106				Manganese-54				
	Pangola hay		Spanish moss			Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining		pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	<15	100	1,220	100	Unwashed	441	100	815	100
0.5N KCl Washed 1 x	<15	0	1,060	87	0.5N KCl Washed 1 x	260	59	367	45
Water Washed 1 x	<15	0	1,100	90	Water Washed 1 x	265	60	386	47
Water Washed 2 x	<15	0	934	76	Water Washed 2 x	115	25	220	27

in these two plants are shown in figures 1 and 2. When either cesium–137 or strontium–85 in aqueous solution is added to ground Spanish moss or Pangola hay it cannot be removed by water washing. Following the addition of a gradually increasing concentration of a KCl solution, complete removal of the added isotope occurred. Thus, Spanish moss did not appear to have an active binding mechanism when the cell structure is damaged. Ground samples of both Spanish moss and Pangola hay acted as a simple ion exchange system.

Summary and conclusion

These preliminary studies indicate that most of the cesium–137 exists on Pangola hay as a lightly bound surface contaminant. This conclusion is supported by the effective removal of cesium–137 by the water washing, and the poor elution of the more tightly bound Manganese–54 without damaging the cell walls. In contrast to this, Spanish moss very tightly

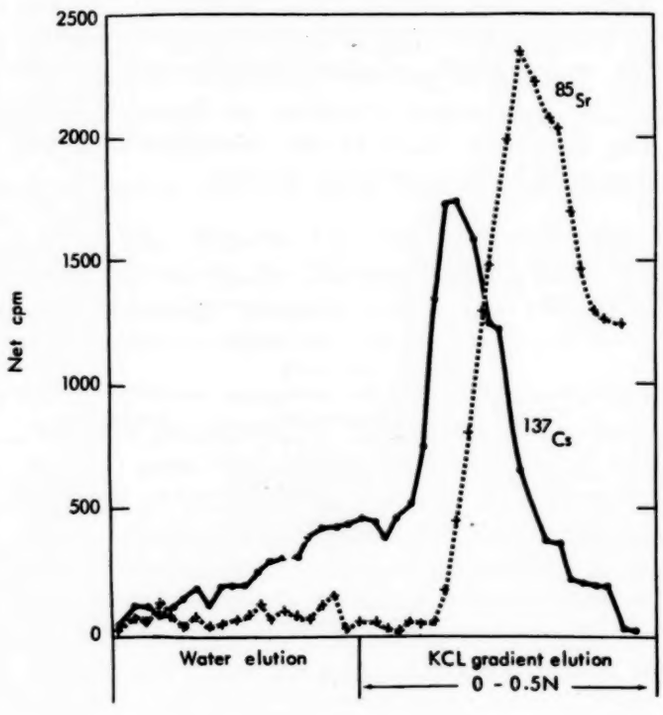

Figure 1. Elution of radionuclides from Pangola hay

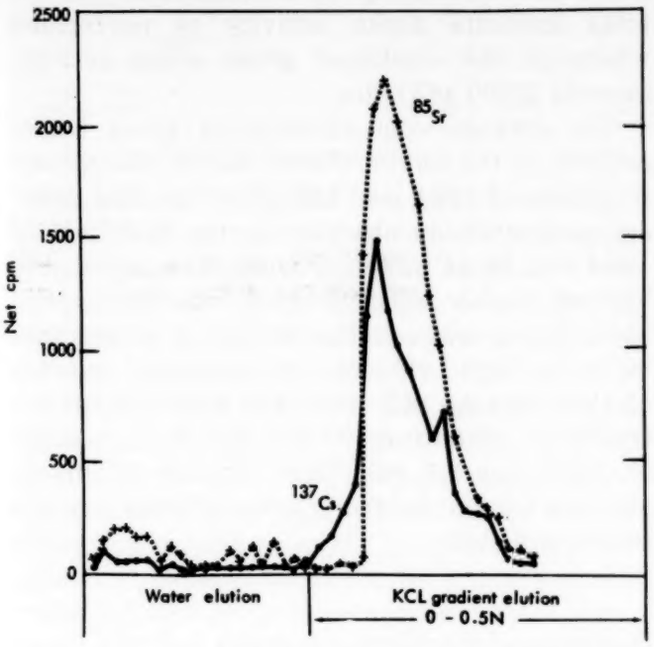

Figure 2. Elution of radionuclides from Spanish moss

binds all of the isotopes detected. When these isotopes settle from the air onto Spanish moss they are actively bound and incorporated into the plant structure. Ionic washing (0.5 KCl) did not remove these nuclides.

When the cell structure of Spanish moss and Pangola hay was damaged by grinding, neither plant actively bound cesium–137 nor strontium –85. The ground material from both plants was comparable to a simple ion exchange system. Thus one is led to conclude that the nuclide binding and uptake of radioisotopes by Spanish moss requires an intact cell structure.

These results have been presented to demonstrate the difference in location and binding of radioactive fallout isotopes. Spanish moss actively binds and retains airborne radioactive isotopes. These radioactive elements are most likely internally bound. Pangola hay has been shown to be high in cesium–137, but this exists as a surface contaminant. If Pangola hay has an active binding mechanism during growth, it appears to be only a surface binding and is lost following cutting and drying.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for the Bettis Atomic Power Laboratory, Feed Materials Production Center, Knolls Atomic Power Laboratory, and SIC Prototype Reactor.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentration limits, are applicable to effluents released from AEC installations.

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Bettis Atomic Power Laboratory[2] July–December 1964

Western Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pennsylvania. Routine environmental monitoring data from the sampling locations shown in figure 1 indicate that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits.

Liquid radioactive waste

Liquid effluent discharged from the Laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta–gamma activity and quaterly for strontium–90 activity. In addition, analysis for total uranium alpha activity is performed whenever the combined gross alpha activity exceeds 2,000 pCi/liter.

The average concentration of gross radioactivity in the liquid effluent during the second 6 months of 1964 was 180 pCi/liter. The average concentration observed in the first half of 1964 was 53 pCi/liter. During this period, the highest weekly concentration was 2,000 pCi/liter. The average concentration of strontium–90 in the liquid effluent for the second quarter of 1964 was 3.5 pCi/liter. The average concentration of strontium–90 for the third quarter of 1964 was 8.1 pCi/liter. The strontium–90 analysis for the fourth quarter of 1964 has not been completed.

Background monitoring stations

Three background monitoring stations are in continuous operation near the Laboratory. These stations continually measure and record the external beta–gamma radiation level. Average readings at these stations are summarized in table 1.

[2] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the Second Six Months of 1964 and for Calendar Year 1964" (PNRO–DEV–132).

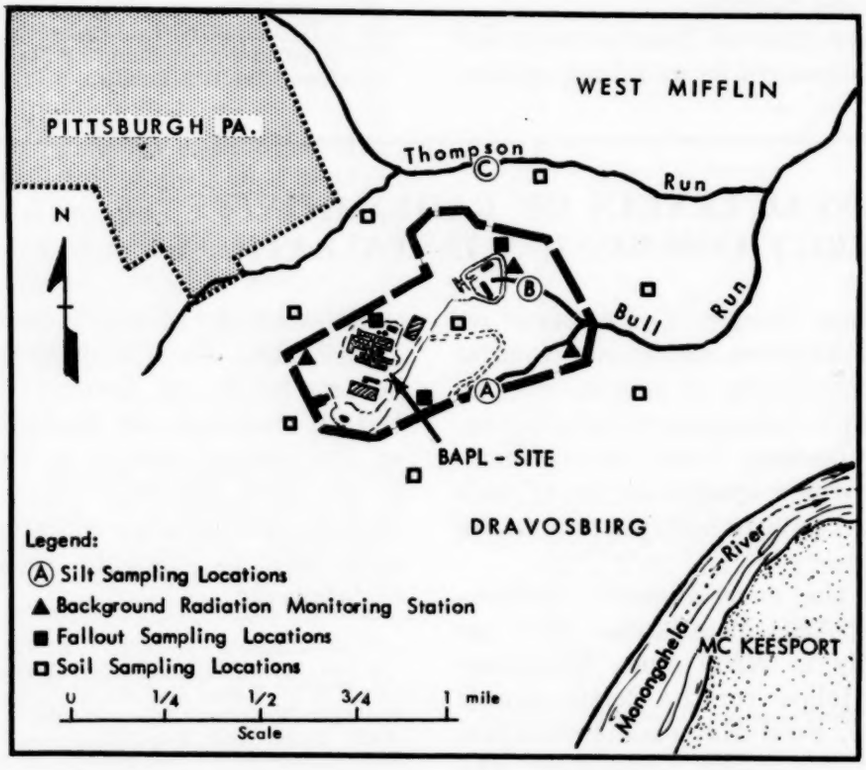

Figure 1. Bettis Atomic Power Laboratory sampling stations

Table 1. Beta-gamma radiation, July–December, 1964

(Average levels in mR/hr)

Station	1	3	4
High weekly level	0.035	0.018	0.269
Low weekly level	0.010	0.010	0.049
Mean	0.014	0.012	0.061

Beta-gamma radiation intensities averaged 0.029 mR/hr during this period. This average represents an increase over the average intensity measured during the first 6 months of 1964, which was 0.016 mR/hr. The increase in the mean beta–gamma activity at Station #4 is due to the proximity of the environmental monitoring detector to the C-Area Critical Facility. During critical operations, the beta–gamma background activity increases and is readily discernible over the periods of reactor shutdown. Normal background levels average from 0.010 to 0.060 mR/hr during reactor shutdown and from 0.8 to 1 mR/hr during reactor operation.

Fallout

Fallout samples are collected at three locations at the perimeter of the Laboratory. Samples are collected over a period of one month in high-wall stainless steel pots, and are analyzed for gross beta activity. The average monthly concentration of radioactive fallout for the second half of 1964 was 3.59 nCi/m². This was a decrease from the 8.61 nCi/m² recorded during the first 6 months of the year.

Soil samples

Soil samples were collected at the eight locations shown in figure 1. None of these samples required analysis, according to the provisions of the operating manual, PNRO–DEV–122.

Stream silt

Soil samples were collected at the eight locations shown in figure 1. The results of analysis of these samples are presented in table 2.

Table 2. Radioactivity in stream silt, July–December 1964

Period	Location	Alpha, pCi/g	Beta-gamma pCi/g
Third quarter, 1964	A	21	22
	B	14	30
	C	27	19
	Average	21	24
Fourth quarter, 1964	A	16	27
	B	27	19
	C	28	12
	Average	24	19

Recent coverage in *Radiological Health Data:*

Period	Issue
July 1961 to June 1962	*April 1963*
July 1962 to June 1963	*April 1964*
July 1963 to December 1963	*November 1964*
January–June 1964	*April 1965*

2. Feed Materials Production Center[3] July–December 1964

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the Center. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium, and with fabricating the metal into fuel elements.

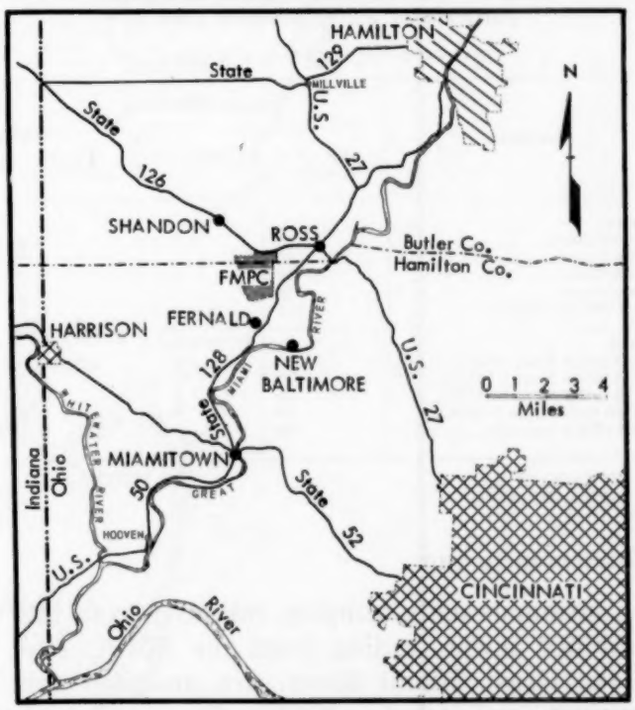

Figure 2. Area map of Feed Materials Production Center

[3] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1964 and Summary Report for 1964" (NLCO–939).

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that releases of radioactive materials to the environment are within AEC and State of Ohio standards.

Air monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers which remove nearly all of the airborne particulates generated during the many plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 3.

Table 3. Radioactivity levels of airborne particulates, July–December 1964

(Average concentrations in pCi/m³)

Location	Second half 1964		
	No. of samples	Uranium [a]	Total activity [b]
Onsite			
Southwest	26	0.2	0.8
Northwest	26	0.1	0.5
Northeast	26	0.2	0.7
Southeast	26	0.1	0.6
All onsite samples	104	0.2	0.7
Offsite			
0–2 miles from FMPC	26	0.1	0.6
2–4 miles from FMPC	22	0.1	0.5
4–8 miles from FMPC	30	0.1	0.5
8–10 miles from FMPC	10	0.1	0.3
All offsite samples	88	0.1	0.5

[a] MPC = 2 pCi/m³.
[b] MPC = 100 pCi/m³.

Water monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken at the locations shown in figure 3.

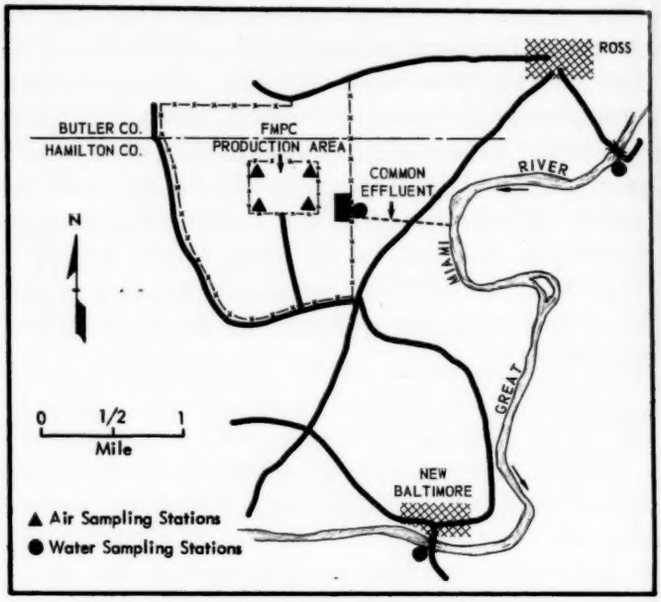

Figure 3. Air and water sampling stations, Feed Materials Production Center

Table 4 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference of the upstream and downstream measurements.

Table 4. Concentrations of uranium and total activity in the Great Miami River, Ohio, July–December 1964

(Average concentrations in pCi/liter)

Location	Method of determination	Second half 1964		
		Number of samples	Uranium [a]	Total activity [b]
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	184	12	20
Upstream	Spot samples	26	5	30
Downstream	Spot samples	30	7	30
Difference		—	2	0

[a] MPC = 20,000 pCi/liter.
[b] MPC = 3,000 pCi/liter.

Recent coverage in *Radiological Health Data:*

Period	Issue
July–December 1960	*June 1961*
January–June 1961	*December 1961*
July 1961–June 1962	*March 1963*
July 1962–December 1963	*May 1964*
January–June 1964	*April 1965*

3. Knolls Atomic Power Laboratory[4] July–December 1964

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Atomic Energy Commission in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site, and the West Milton site, located as shown in figure 4. The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; and critical assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facility. Regular environmental monitoring activities are conducted to assure that Laboratory releases of radioactivity to the environment are in compliance with AEC standards. The data that follow indicate that Laboratory waste operations have complied with AEC requirements.

[4] Summarized from "Knolls Atomic Power Laboratory Semiannual Environmental Monitoring Report, July–December 1964" (Volume 6, Number 2).

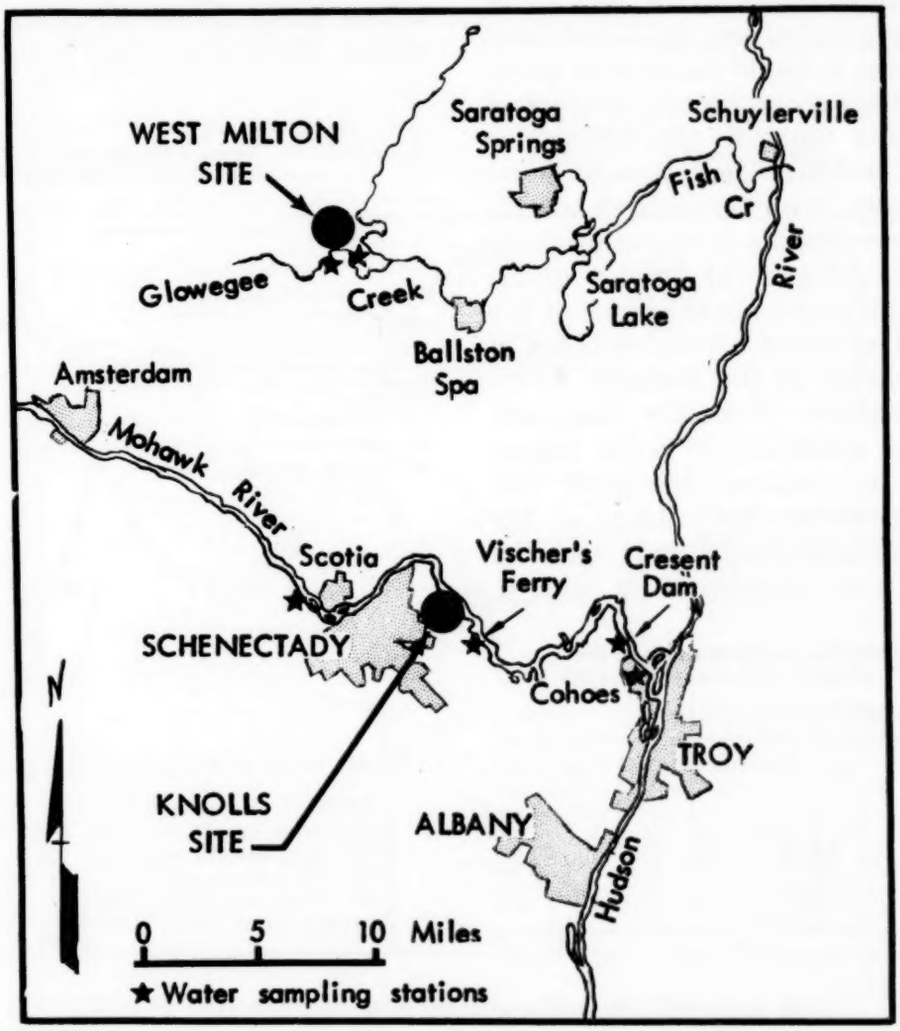

Figure 4. Environmental monitoring locations, KAPL

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory, approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The results of the airborne radioactivity analyses are given in table 5. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the naturally occurring short-lived materials to decay.

Table 5. Airborne beta activity, KAPL, July–December 1964

Sampling locations	Concentrations, pCi/m³
Knolls site	0.33
West Milton site	0.38
Research Laboratory	0.33

Liquid waste monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to (1) the concentration of fission products in the collection tanks, and (2) the flow of the river. A continuous proportional sample of the Knolls site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium–90 is the principal component to be considered in control. The amounts and the radionuclide content of the combined sewer effluent discharged from the Knolls site have been summarized in table 6.

Table 6. Radionuclide concentrations in the Knolls site waste effluent, July–December 1964

(Average concentrations in pCi/liter)

Radionuclides	Concentrations	AEC Standards
Strontium-89	4.1	3,000
Strontium-90	120	300
Cesium-137	240	20,000
Cerium-144—Praseodymium-144	37	10,000
Ruthenium-106	4.1	10,000
Iodine-131	4.1	300

A total of 93.0 millicuries of beta activity was discharged to the Mohawk River during the 6–month period at monthly average concentrations ranging from 230 to 770 pCi/liter.

Since Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of .1 millicuries was discharged at two points into Glowegee Creek during the six–month period at monthly average concentrations ranging from 245 to 336 pCi/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Mohawk River water is sampled continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse eight miles upstream from the site; at the Visher Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results are given in table 7.

Table 7. Gross beta-gamma activity in streams receiving effluents, July–December 1964

Streams and locations	Concentrations, pCi/liter
Mohawk River (Knolls site):[a]	
G.E. Powerhouse (upstream)	6
Vischer Ferry (downstream)	4
Cohoes (downstream) raw-water	5
Cohoes (downstream) finished drinking water	5
Glowegee Creek (West Milton site):[a]	
Upstream	13
Downstream	15

[a] MPC 100 pCi/liter.

Recent coverage in *Radiological Health Data:*

Period	Issue
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1962–December 1963	*June 1964*
January–June 1964	*April 1965*

4. S1C Prototype Reactor Facility [5] July–December 1964

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land-based nuclear submarine power plant facility containing a pressurized water reactor power plant which is used for research, development, and training. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations. Monitoring results which follow indicate that the Facility has fully complied with the prescribed standards of the AEC.

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 8 and 9 give the average beta concentrations of airborne and liquid wastes before release to the environment.

[5] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, July 1 to December 31, 1964" (CENRD-3163-RS-499).

Table 8. Airborne beta activity, S1C July–December 1964

Sampling locations	Concentrations, pCi/m³
Stack discharge	46
Onsite average	0.41
Offsite average	0.53

Table 9. Radioactivity in liquid wastes discharged into the Farmington River, S1C, July–December 1964

Activity	Quantity
Total beta activity (millicuries)	9.2
Average gross beta concentrations (pCi/liter):	2,100
Cobalt-60	1,900
Iron-59	72
Manganese-54, Cobalt-58	330

Figure 5 shows the locations of 6 water sampling stations along the Farmington River and of 17 fallout monitoring stations. Comparisons of the data for upstream and downstream water and mud samples showed no significant difference from background during the period reported. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of *Radiological Health Data.*

Recent coverage in *Radiological Health Data:*

Period	Issue
January–July 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1963–December 1963	*June 1964*
January–June 1964	*April 1965*

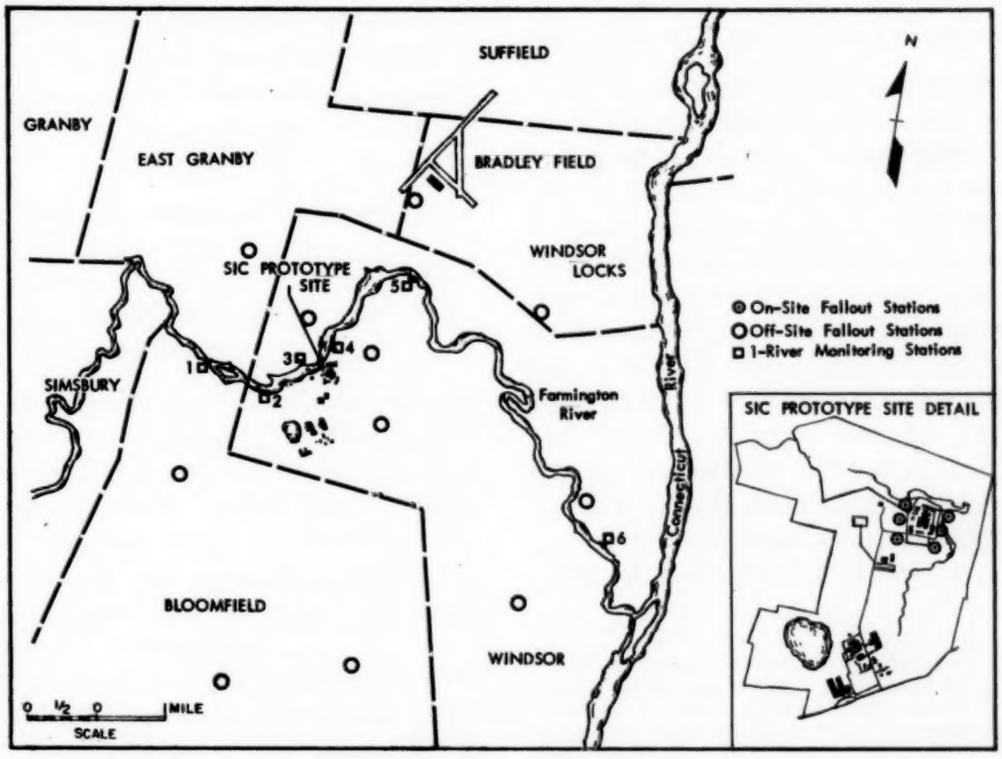

Figure 5. Environmental monitoring locations, S1C Prototype Site